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# Travel in the Triangle

## TRENDS IMPLEMENTATION CHOICES

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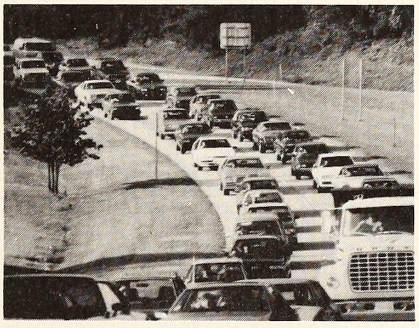
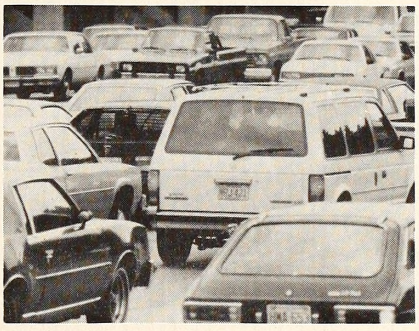
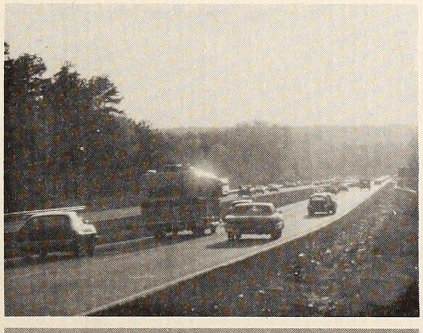
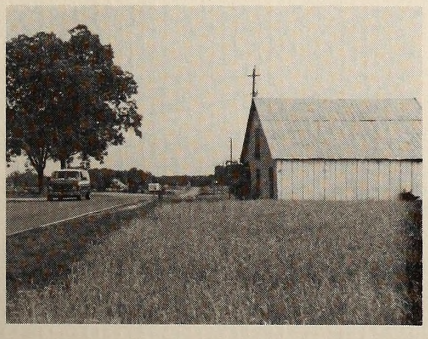
June 1986

# Travel in the Triangle









T R E N D S

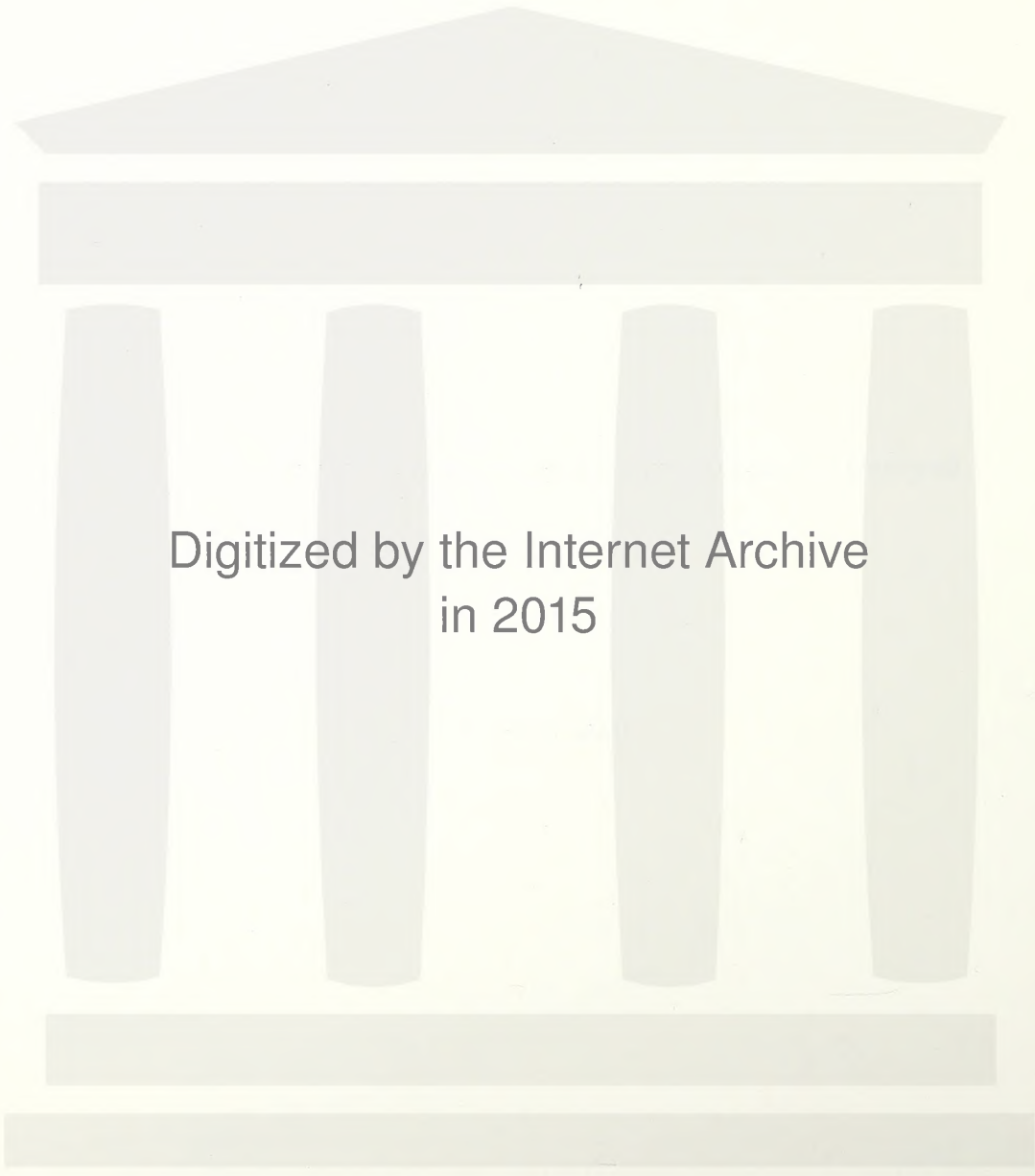
# TRAVEL IN THE TRIANGLE: TRENDS

Report No. 1

Research Triangle Area Public Transportation Study

June 1986

Department of City and Regional Planning
University of North Carolina
Chapel Hill, NC 27514



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# PREFACE

This report is the first in a series of three from the Research Triangle Area Public Transportation Study. Report No. 2, "Travel in the Triangle: Choices," presents an analysis of public transportation service options for the region. The third report, "Travel in the Triangle: Implementation," presents proposals for implementing new public transportation services in the Triangle.

The Research Triangle Area Public Transportation Study is funded by the North Carolina Department of Transportation and the Urban Mass Transportation Administration. It is conducted jointly by researchers from the University of North Carolina, North Carolina State University, and Duke University.

This report has benefited substantially from the important contributions of numerous individuals. The traffic data and many of the projections were provided by the Thoroughfare Planning Unit of the N.C. Department of Transportation. Staff members of the Division of Public Transportation at the N.C. Department of Transportation provided critical suggestions for improving the text and graphs. They also handled the printing and production of this report. Finally, members of the study steering committee provided important suggestions at several critical points in the development of this report. To all these persons, we extend our sincere appreciation.

# TRAVEL IN THE TRIANGLE: TRENDS

## Executive Summary

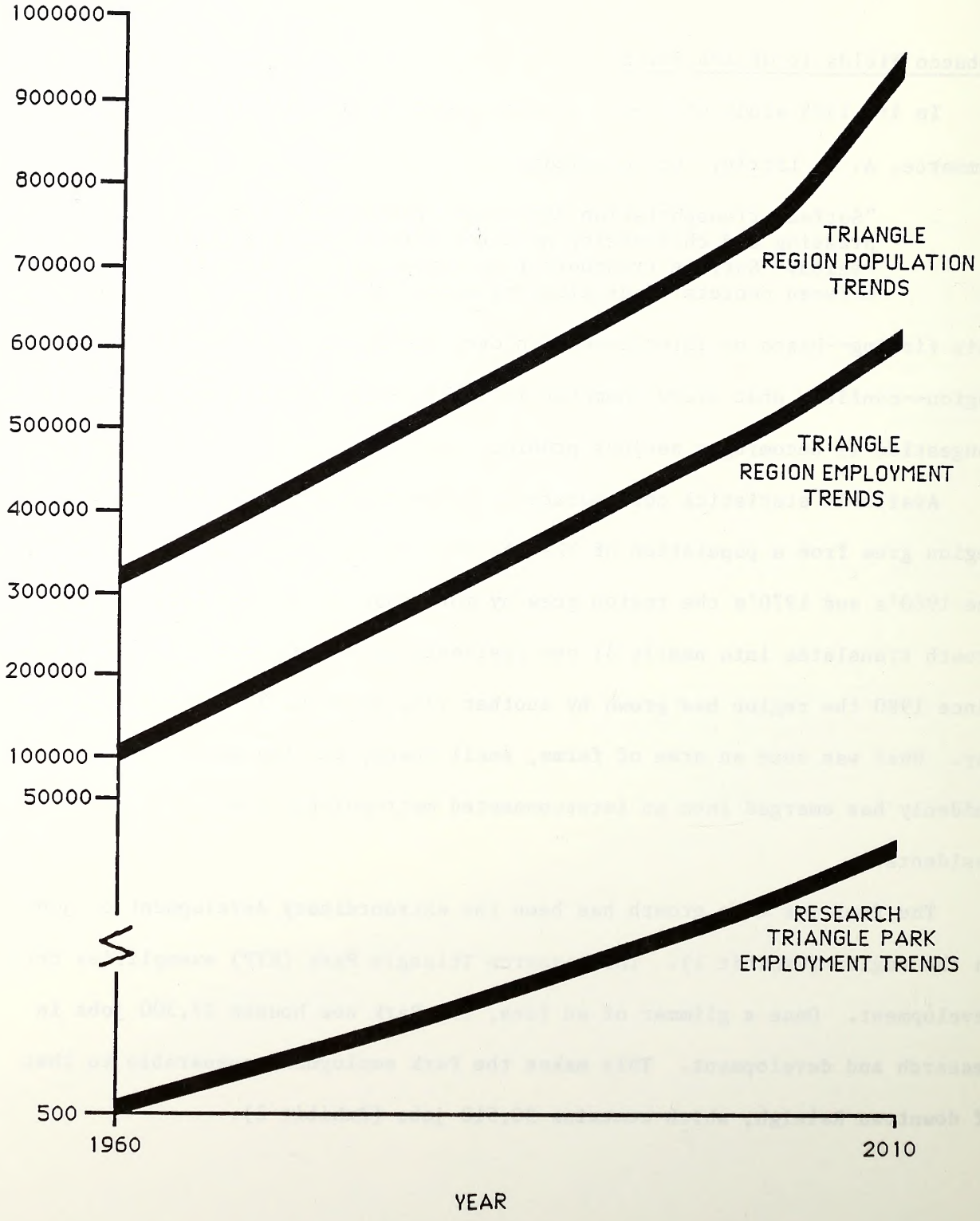
The Raleigh Chamber of Commerce 1985 study of economic development states that traffic congestion is becoming a serious problem in the Triangle. Statistics confirm this conclusion. The three-county regional population grew by more than 60% from 1960 to 1980 and another 11% since 1980. An area that was at one time farms and small towns is now an inter-connected metropolitan region with about 600,000 residents. The cause of this growth has been the tremendous development of jobs in the region.

Traffic congestion is made worse by the intense inter-area commuting that exists. The Triangle area has heavy traffic flowing in virtually all directions, and this heavy commuting is served by only five major highway corridors.

The congestion problem will only worsen in the future. Predictions show that the population of the region will exceed 800,000 early in the century. Analysis of the major highway corridors in the region shows that before the year 2010 nearly all the corridors will be at or above capacity even with the building of additional lanes.

EXHIBIT 1

# THE TRIANGLE REGION



Where once there stood pine forests there now exists the third largest business district in the state. Tobacco fields have become condominiums and office parks.

People and jobs mean cars and congestion. Over 19,000 vehicles enter the Park during each morning peak period. These vehicles average between 1.08 and 1.22 persons per vehicle. This low occupancy rate has a clear and critical meaning for the region. Fast growth in jobs means an equally fast growth in traffic. For an area with roads suitable for a once-rural density, the rapid increase in traffic has an obvious result: congestion.

## Travel Patterns

Traffic congestion would be eased if more of us lived closer to our work places, schools, and shopping areas. However, we do not. Each day many of us travel long distances across the region. In fact, it is this intense, inter-area commuting which binds the cities and towns together as an inter-dependent region.

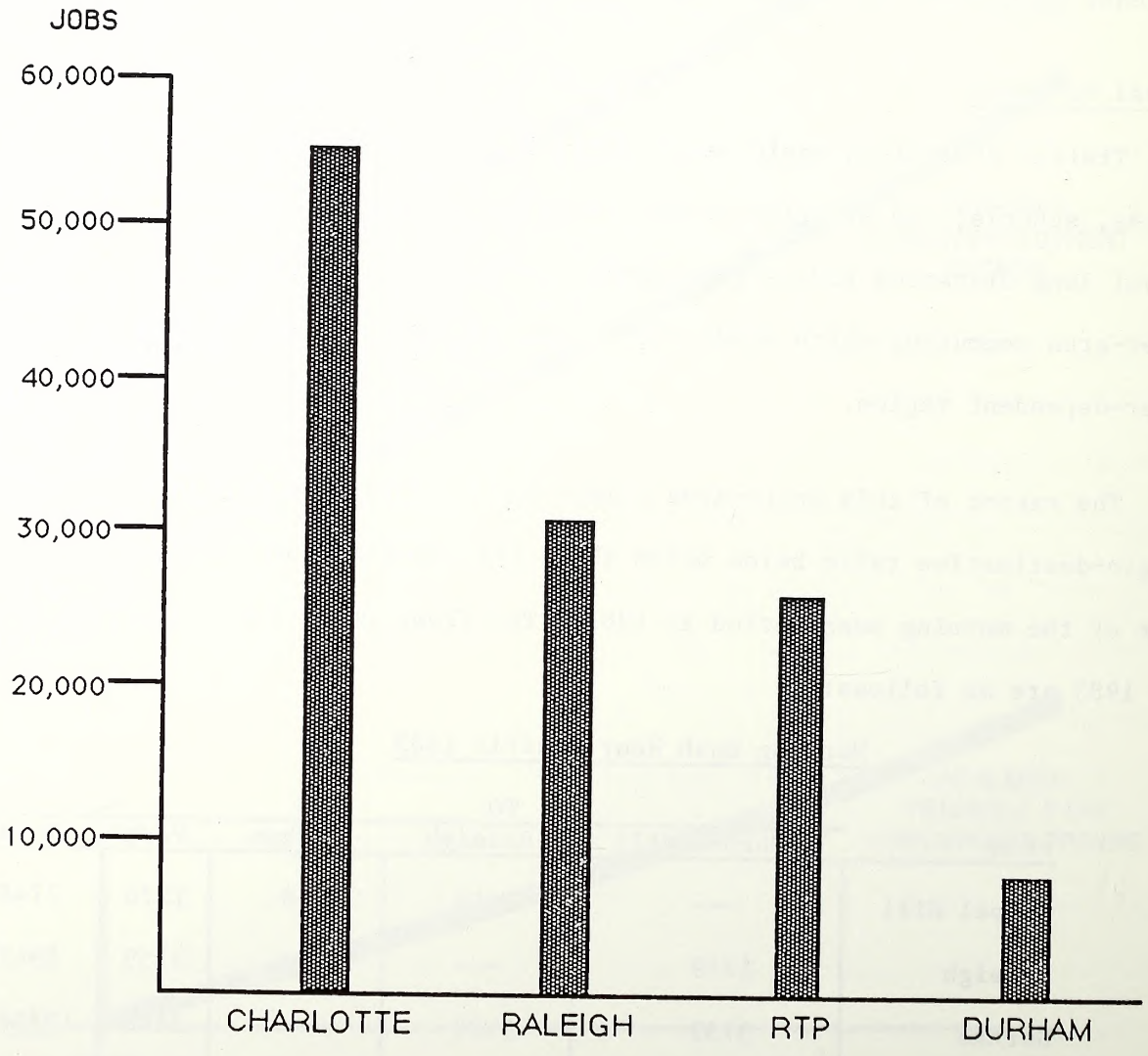
The extent of this inter-area commuting is illustrated in the origin-destination table below which shows the typical flows during just one hour of the morning peak period in 1983. The flows among the principal cities for 1983 are as follows:

Morning Rush Hour Traffic 1983

| | TO | | | | |
|---|---|---|---|---|---|
| FROM | Chapel Hill | Raleigh | Durham | Park | Totals |
| Chapel Hill | --- | 2412 | 3958 | 1376 | 7746 |
| Raleigh | 1719 | --- | 3863 | 3359 | 8941 |
| Durham | 3739 | 5189 | --- | 3640 | 12568 |
| TOTALS | 5458 | 7601 | 7821 | 8375 | 29255 |

EXHIBIT 2

# RTP EMPLOYMENT COMPARED TO OTHER DOWNTOWNS: 1986



The numbers in this table are vehicles during one hour; the number of persons traveling between any two cities can be found by multiplying the vehicle-trips by the average vehicle occupancy rate. For example, the 3863 peak-hour vehicles traveling from Raleigh to Durham represent about 4442 persons.

The origin-destination table clearly shows the multi-directional nature of traffic in the region. Unlike major metropolitan areas in which traffic predominately flows toward the central business district in the morning and toward the suburbs in the afternoon peak, the Triangle area has heavy traffic flowing in virtually all directions. For example, the vehicular flows between Durham and Chapel Hill are about equal (3739 vs. 3958) in both directions. This bi-directional flow is, of course, the result of the fact that the region contains several major employment centers, each of which attracts employees from across the region.

These traffic flows are handled by only five major highway corridors, each of which is burdened by the demand placed on it. The result, predictably, is heavy congestion. Exhibit 3 shows typical morning peak-hour traffic volumes on the principal highway segments. For example, I-40 between Raleigh and the Park currently averages about 7600 vehicles per hour during the morning peak. US 15-501 handles 3800 vehicles and NC 54 from Chapel Hill to the Park carries 3000. These volumes approximate the total flow in both directions. It is important to note that there are high rush hour "peaking" characteristics in the traffic flows. Exhibit 4 shows the traffic peaks during the rush hour on I-40, and how the peak exceeds the Level of Service "D" capacity. At this condition traffic moves slowly and may momentarily stop. Similar peaking problems exist on all RTP area roads. If the rush hour volume could be spread over a longer period, congestion could be reduced significantly.

EXHIBIT 3

# MORNING RUSH HOUR TRAFFIC IN MAJOR CORRIDORS (1983)

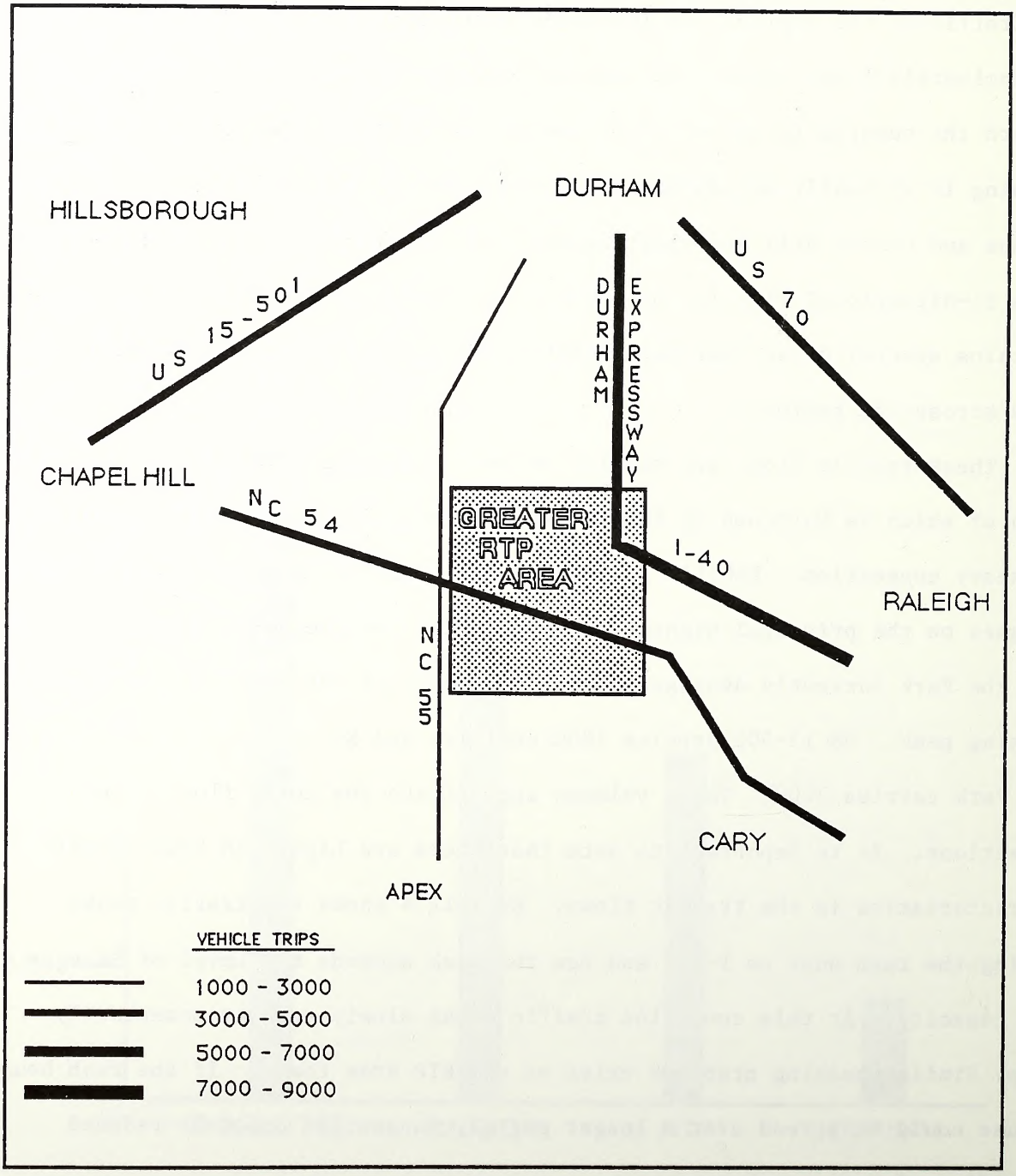
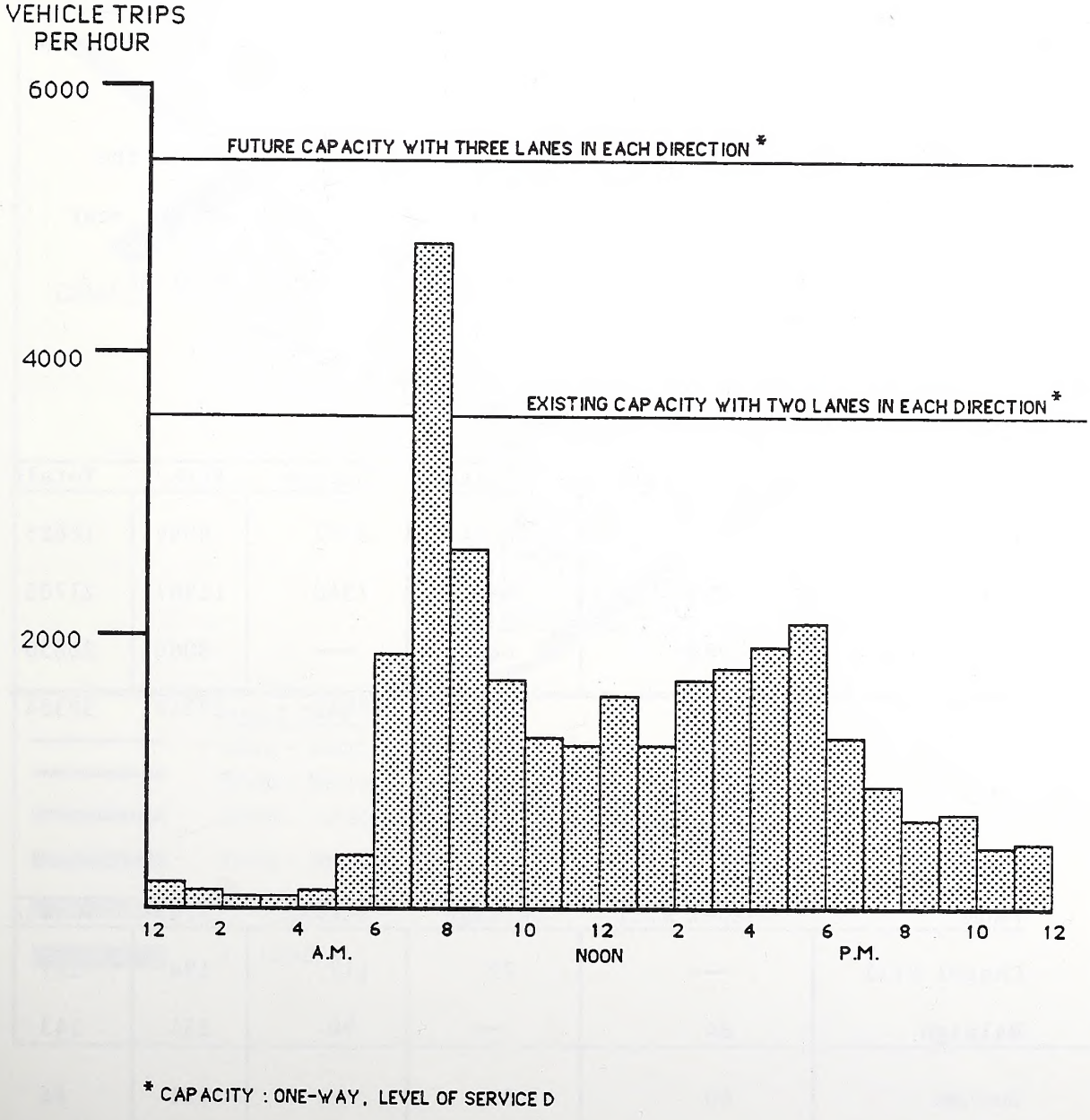


EXHIBIT 4

# HOURLY TRAFFIC DATA (1986)
# RALEIGH TO GREATER RTP AREA
# I-40 (EAST OF AVIATION PARKWAY)




* CAPACITY : ONE-WAY, LEVEL OF SERVICE D

## The Future

An Chinese proverb states: prediction is difficult, especially with respect to the future. This proverb is no less true with respect to the Triangle region as we look beyond the next few years.

Present building patterns, however, provide clear evidence about what the next few years will bring. Major developments are being constructed or planned throughout the region. These projects indicate that by the year 2000 the population of the region will reach 828,440. Employment within the Park alone will exceed 30,000 by 1990 and will approach 40,000 by the turn of the century. By 2010 employment within the Greater RTP area, which extends from N.C. 55 to the aiport, will grow beyond 100,000.

Predictions beyond the next few years have been made as part of the thoroughfare plans for cities within the region. The predictions for year 2005 show that traffic flows will continue to increase dramatically as indicated in the tables below and in Exhibit 5.

Morning Rush Hour Traffic 2005

| | TO | | | | |
|---|---|---|---|---|---|
| FROM | Chapel Hill | Raleigh | Durham | Park | Totals |
| Chapel Hill | --- | 4184 | 8597 | 4044 | 16825 |
| Raleigh | 3156 | --- | 7340 | 11207 | 21703 |
| Durham | 5988 | 6800 | --- | 8068 | 20856 |
| Totals | 9144 | 10984 | 15937 | 23319 | 59384 |

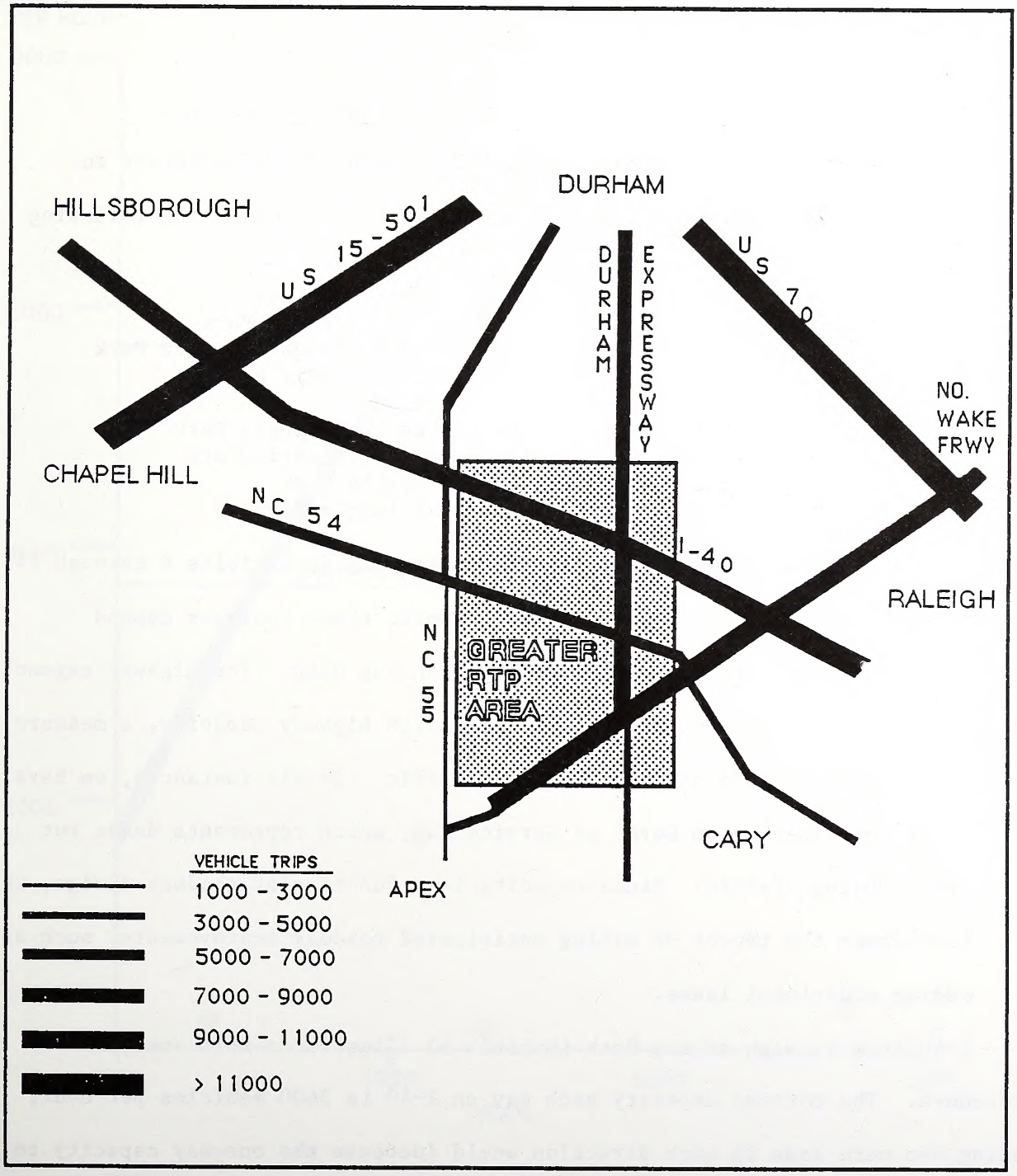
Morning Rush Hour Traffic
Percent Increases, 1983-2005

| | TO | | | | |
|---|---|---|---|---|---|
| FROM | Chapel Hill | Raleigh | Durham | Park | Totals |
| Chapel Hill | --- | 72 | 117 | 194 | 117 |
| Raleigh | 84 | --- | 90 | 234 | 143 |
| Durham | 60 | 31 | --- | 121 | 66 |
| Totals | 68 | 45 | 104 | 178 | 103 |

EXHIBIT 5

# MORNING RUSH HOUR TRAFFIC IN MAJOR CORRIDORS (2005)

(ASSUMES NORTHERN WAKE FREEWAY AND CARY-DURHAM PARKWAY ARE BUILT)



These percentages show major increases in regional morning rush hour traffic, especially to the Greater RTP area. Comparing the total morning rush hour traffic on the regional network of highways in 1983 to that in the year 2005, it is seen that traffic increases from 29,255 to 59,384, an increase of of 103%.

## Corridor Analysis

To understand the full impact of traffic growth, it is necessary to examine specific highways. For this analysis we have examined the following highways:

I-40, Raleigh to the Research Triangle Park
I-40, Chapel Hill to the Research Triangle Park
Durham Expressway, Durham to the Research Triangle Park
U.S. 70, Raleigh to the Research Triangle Park
U.S. 15-501, Chapel Hill to Durham
NC 54, Raleigh/Cary to the Research Triangle Park
NC 54, Chapel Hill to the Research Triangle Park
NC 55, Apex to the Research Triangle Park
NC 55, Durham to the Research Triangle Park

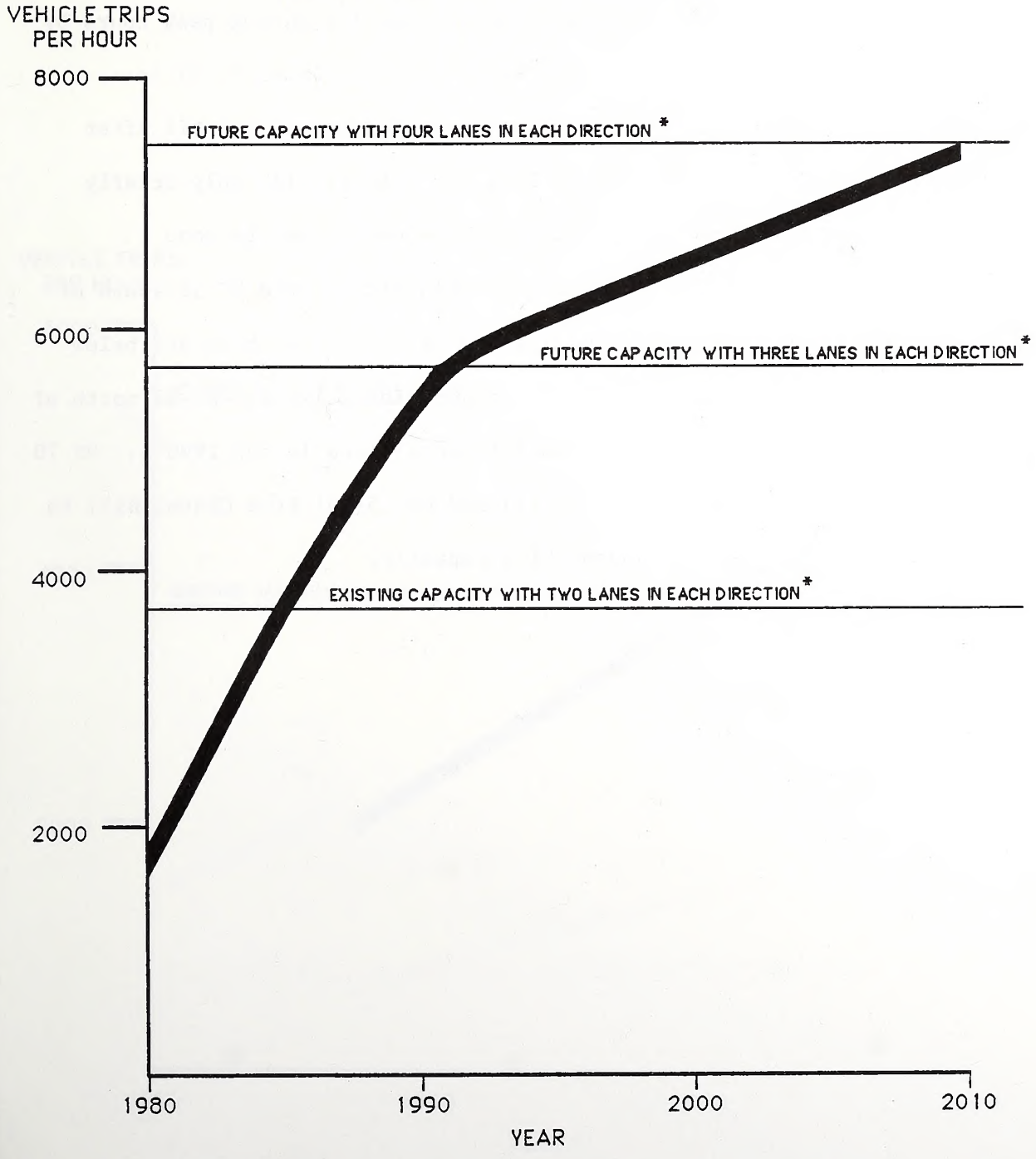
Each of these highway segments is treated separately in Exhibits 6 through 14.

As with all the traffic data in this report, these analyses depend heavily on data from the Thoroughfare Planning Unit. The highway segment analysis compares expected traffic flow with highway capacity, a measure of the ability of a highway to carry traffic. In all instances, we have based the capacity on Level of Service "D", which represents dense but free-flowing traffic. Since capacity is a function of roadway design, we have shown the impact of making anticipated roadway improvements, such as adding additional lanes.

I-40 from Raleigh to the Park (Exhibit 6) illustrates this analysis procedure. The current capacity each way on I-40 is 3600 vehicles per hour; adding one more lane in each direction would increase the one-way capacity to 5550. Comparing the expected peak-hour traffic with the capacities shows that

EXHIBIT 6

# MORNING RUSH HOUR TRAFFIC RALEIGH TO GREATER RTP AREA I-40 (EAST OF AVIATION PARKWAY)



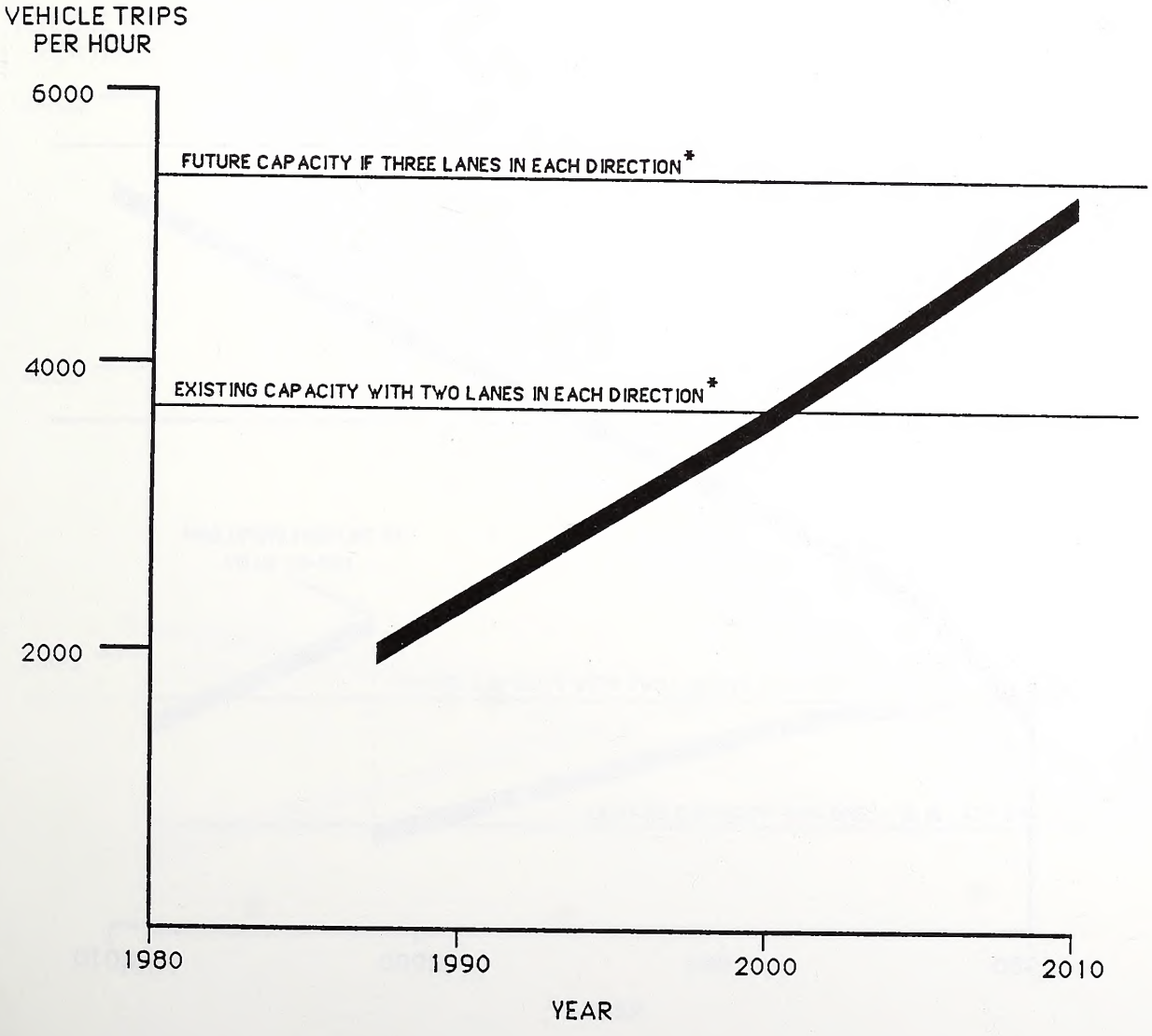

* CAPACITY : ONE-WAY, LEVEL OF SERVICE D

the existing roadway is already over capacity, and that the roadway would be at capacity during peak hours by 1990 even with an additional lane in each direction.

For the other segments the results vary. The new segment of I-40 between Chapel Hill and the Park (Exhibit 7) will be at capacity during peak hours by 2000 without an additional lane. The Durham expressway (Exhibit 8) is operating satisfactorily and will not exceed existing capacity until after 1995. NC 54 between Chapel Hill and the Park (Exhibit 9) will only briefly drop below capacity once I-40 is opened and then reach capacity soon thereafter. NC 54 between Cary and the Park (Exhibit 10) and NC 55 south of NC 54 (Exhibit 11) are both already well above capacity, but both are below the capacities that would result from adding additional lanes. NC 55 north of the Park (Exhibit 12) will not reach capacity until late in the 1990's. US 70 in the vicinity of the airport (Exhibit 13) and US 15-501 from Chapel Hill to Durham (Exhibit 14) are rapidly approaching capacity.

EXHIBIT 7

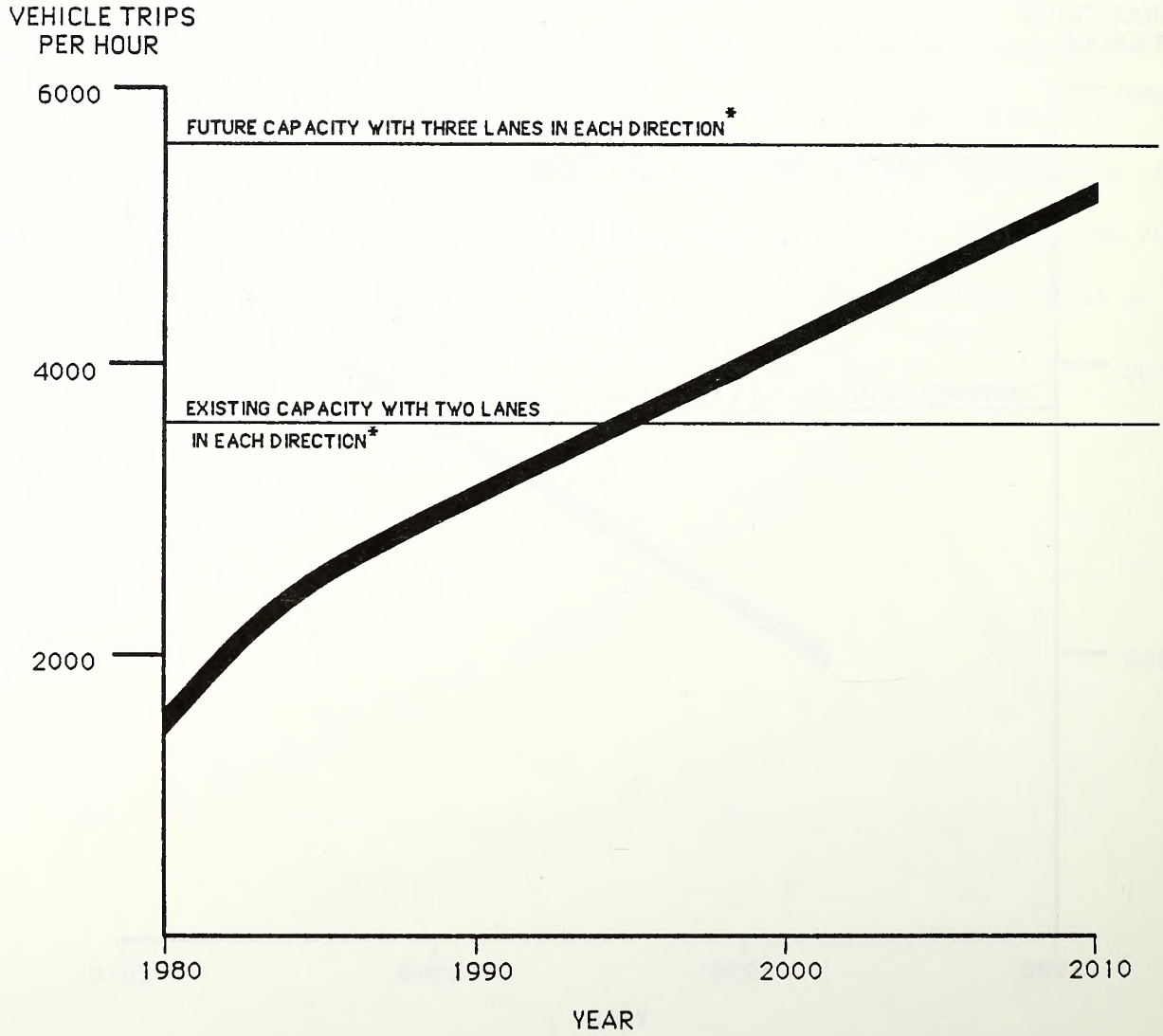
# MORNING RUSH HOUR TRAFFIC CHAPEL HILL / HILLSBOROUGH TO THE GREATER RTP AREA, I-40 (EAST OF NC 54) (SECTION OPENS 1987-1988)




* CAPACITY : ONE-WAY, LEVEL OF SERVICE D

EXHIBIT 8

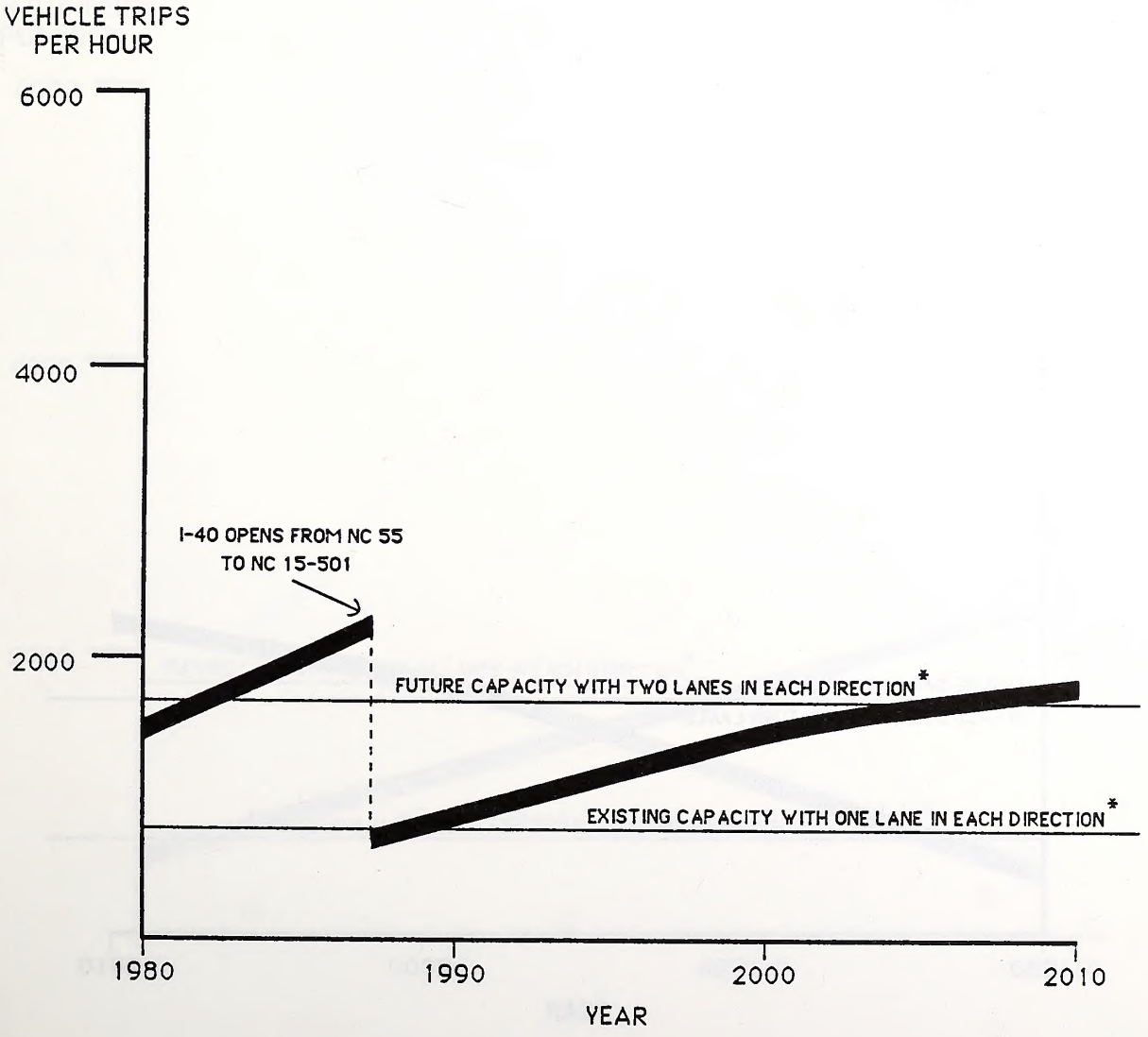
# MORNING RUSH HOUR TRAFFIC
# DURHAM TO GREATER RTP AREA
# DURHAM FREEWAY (NORTH OF ALEXANDER DR.)




* CAPACITY : ONE-WAY, LEVEL OF SERVICE D

EXHIBIT 9

# MORNING RUSH HOUR TRAFFIC CHAPEL HILL TO GREATER RTP AREA NC 54 (WEST OF NC 55)

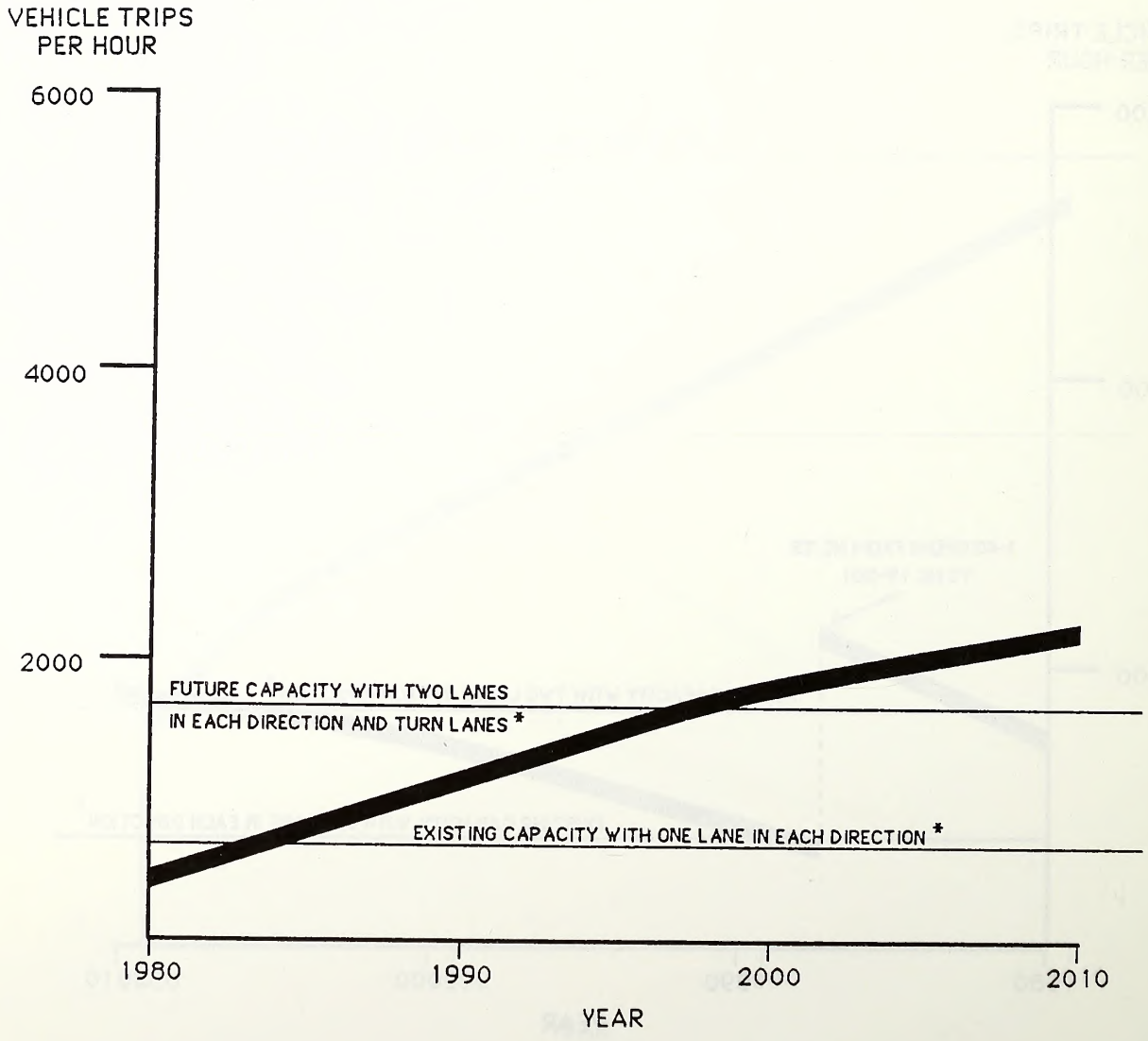



* CAPACITY : ONE-WAY, LEVEL OF SERVICE D

EXHIBIT 10

# MORNING RUSH HOUR TRAFFIC RALEIGH / CARY TO GREATER RTP NC 54 (WITHIN RTP)

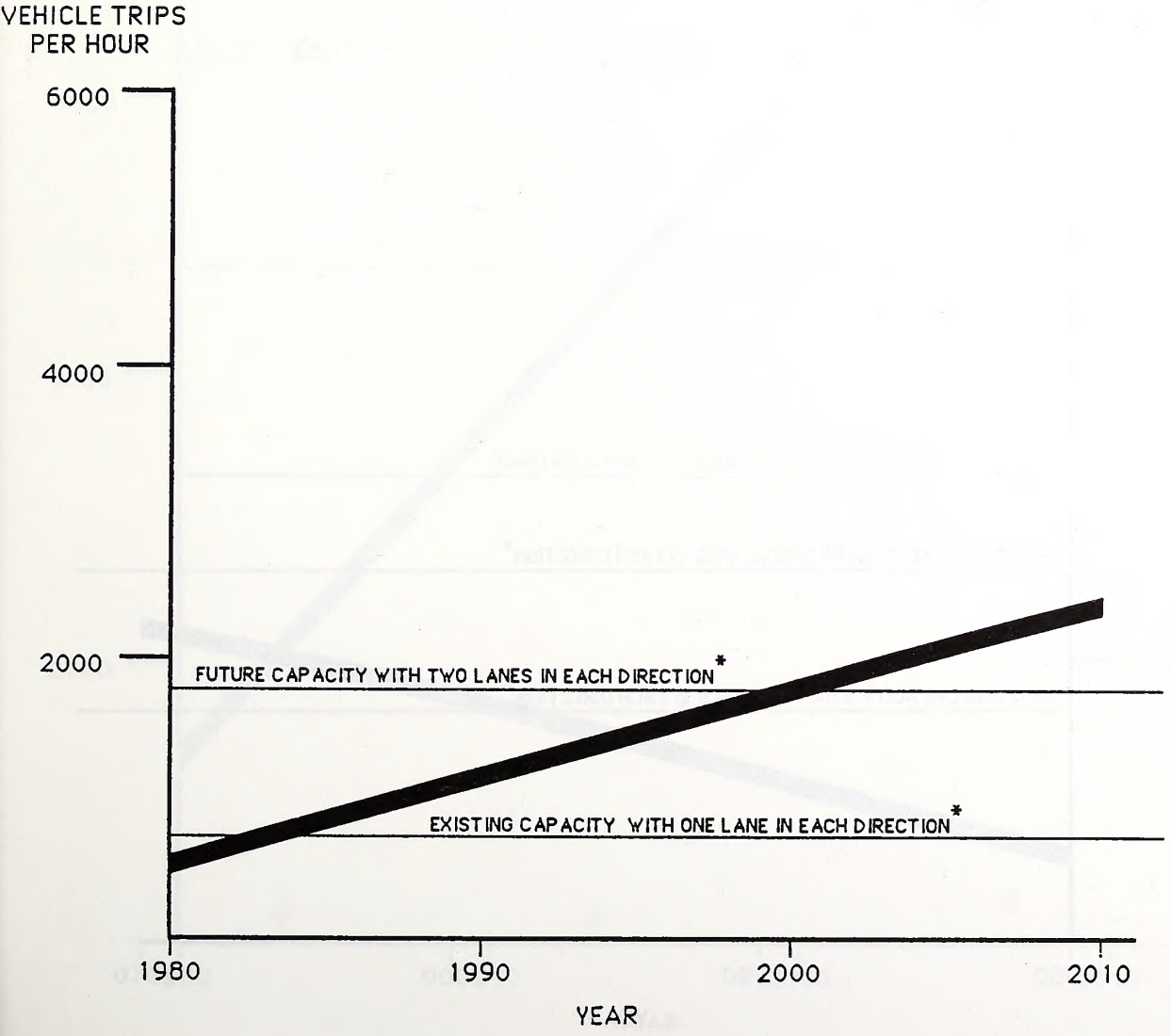
(PROJECTIONS ASSUME CARY-DURHAM PARKWAY IS BUILT)




* CAPACITY : ONE-WAY, LEVEL OF SERVICE D

EXHIBIT 11

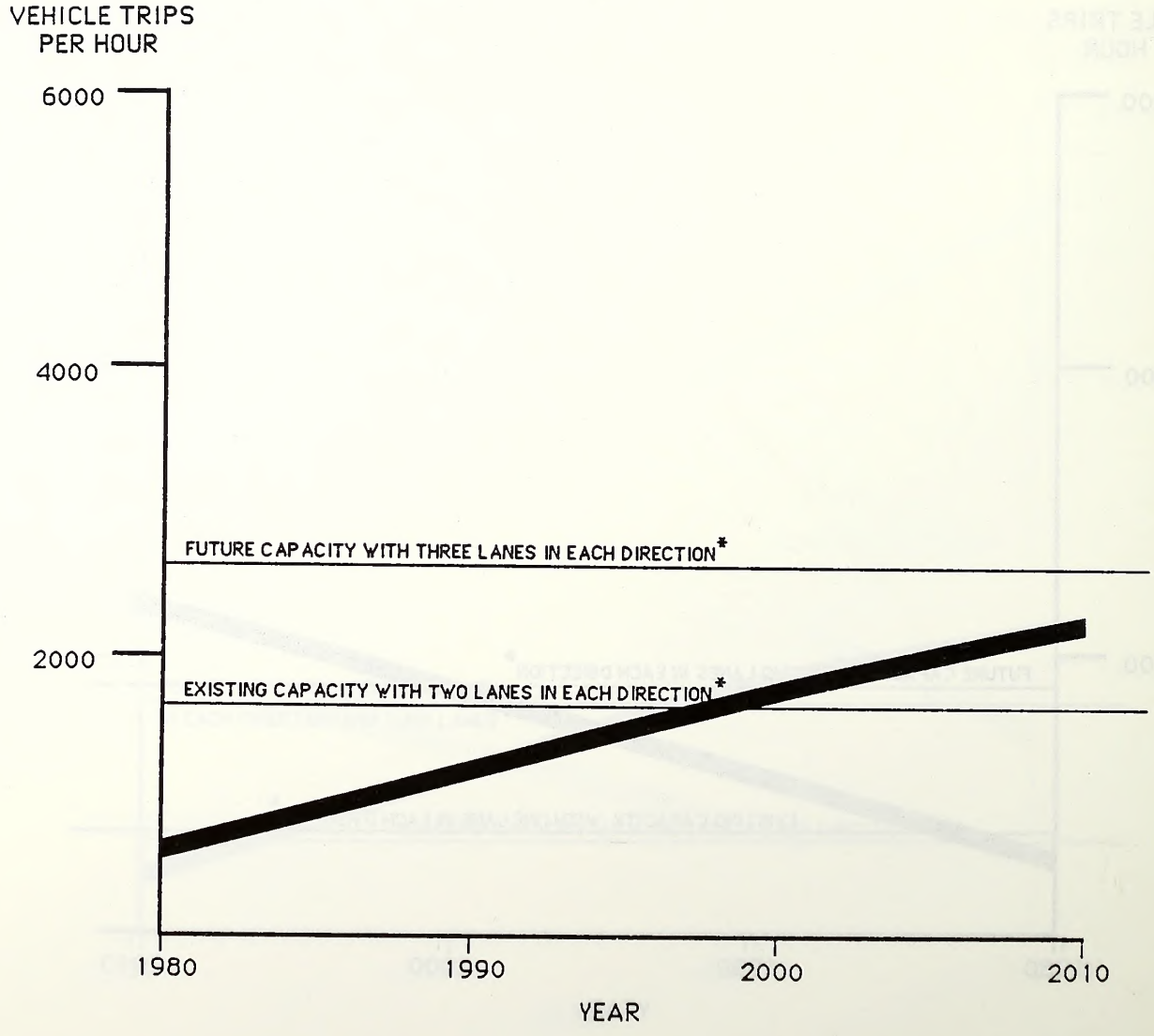
# MORNING RUSH HOUR TRAFFIC APEX TO GREATER RTP AREA NC 55 (SOUTH OF NC 54)




* CAPACITY : ONE-WAY, LEVEL OF SERVICE D

EXHIBIT 12

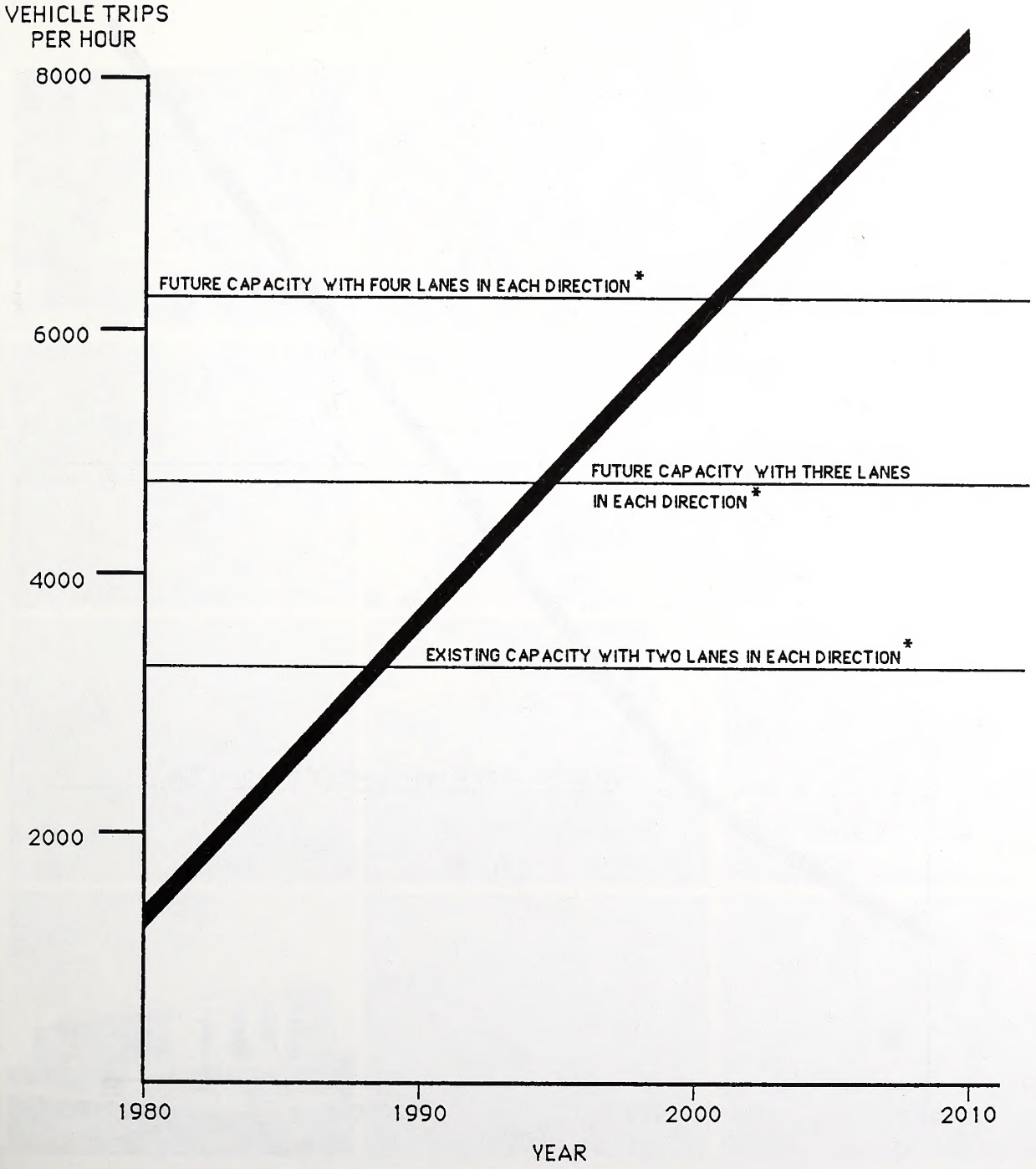
# MORNING RUSH HOUR TRAFFIC DURHAM TO THE GREATER RTP AREA NC 55 (NORTH OF CORNWALLIS RD.)




* CAPACITY : ONE-WAY, LEVEL OF SERVICE D

EXHIBIT 13

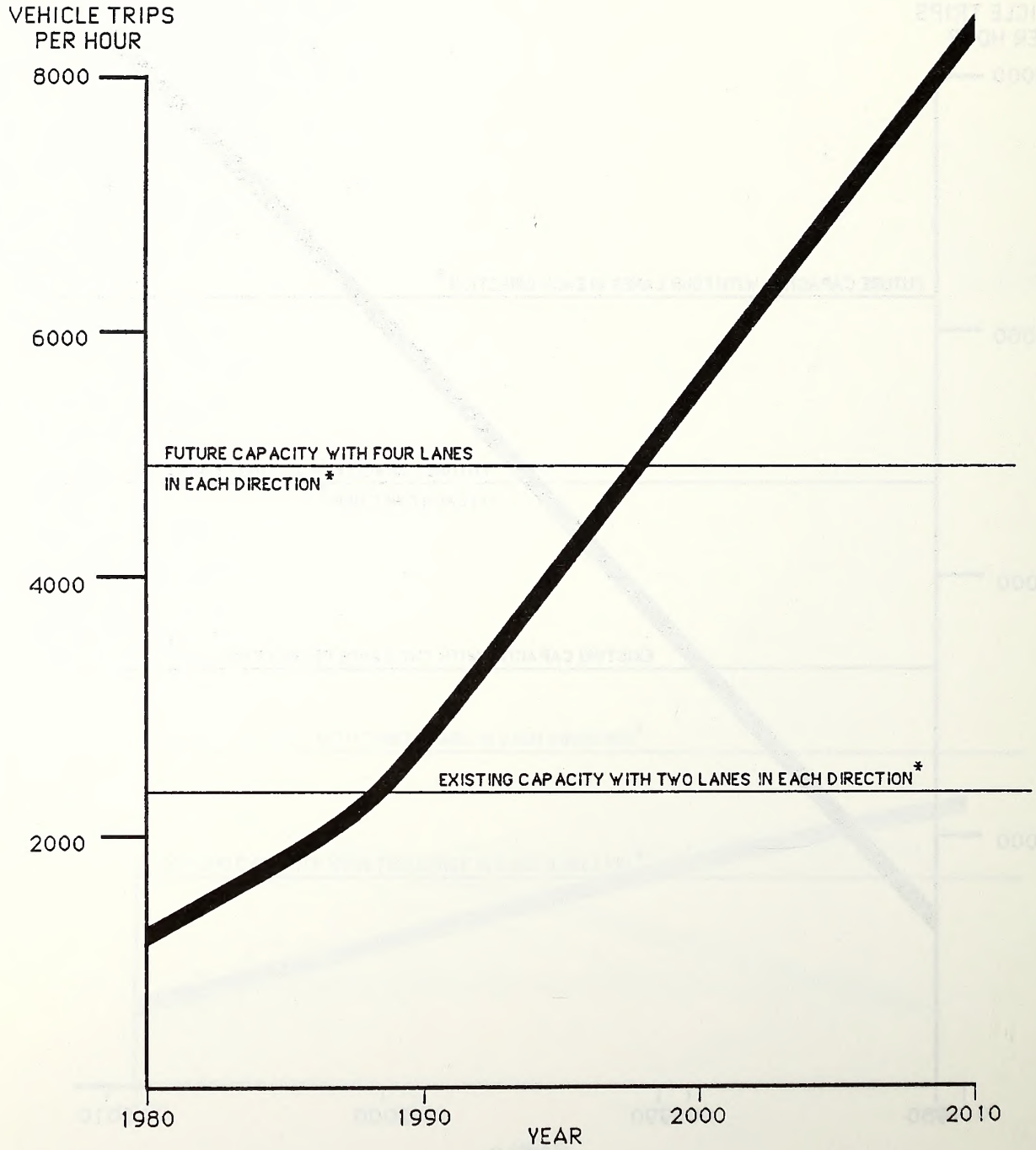
# MORNING RUSH HOUR TRAFFIC RALEIGH TO GREATER RTP AREA U.S. 70 (EAST OF AVIATION PARKWAY




* CAPACITY : ONE-WAY, LEVEL OF SERVICE D

EXHIBIT 14

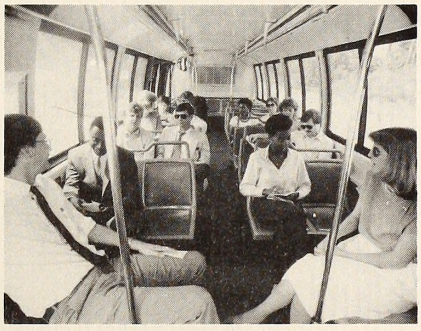
# MORNING RUSH HOUR TRAFFIC CHAPEL HILL TO DURHAM U.S. 15-501 (WEST OF I-40)

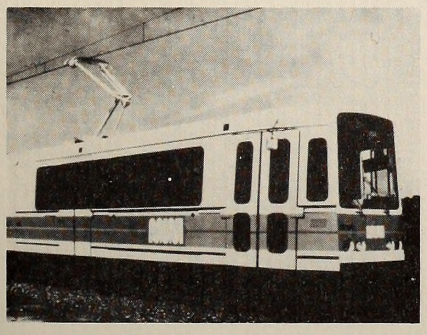



* CAPACITY : ONE-WAY, LEVEL OF SERVICE D

March 1987

# Travel in the Triangle





# C H O I C E S

# TRAVEL IN THE TRIANGLE: CHOICES

Report No. 2

Research Triangle Area Public Transportation Study

March 1987

Department of Civil Engineering
North Carolina State University
Raleigh, NC

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# PREFACE

A series of three reports document this project on public transportation problems and opportunities for the Research Triangle Area. Report No. 1, "Travel in the Triangle: Trends", describes how the area has grown in population and employment with a consequent growth in traffic congestion. Data in the report illustrate the amount of traffic on the major highways and how planned roadway improvements will fall short of meeting the increased demand for regional travel.

This report is the second of the series. It discusses public transportation options that may be used to complement highway travel, not substitute for badly needed highway improvements. It shows which options are best suited to the region's commuting and land use characteristics, and it develops approximate costs and service characteristics for the options. As a guide to the reader, Section 1 explains the study methodology, and Section 2 identifies the feasible options and explains why they are suitable to this area. Each of the remaining sections is devoted to a preliminary "sketch plan" analysis of the options. The Executive Summary includes brief descriptions for feasible public transportation services in the I-40 corridor, comparison factors for the I-40 services, and recommendations.

Report No. 3, "Travel in the Triangle: Implementation", proposes organizational options for delivering regional public transportation service. This third and last report in the series discusses options for organizing public and private entities in the Triangle in order to provide needed public transportation services.

The three reports represent the results of the Triangle Area Public Transportation Study which was funded by the North Carolina Department of Transportation and the Urban Mass Transportation Administration. The study was conducted by a research team composed of faculty and graduate students from North Carolina State University, the University of North Carolina at Chapel Hill, and Duke University. Copies of the reports may be obtained from the Public Transportation Division, North Carolina Department of Transportation, PO Box 25201, Raleigh, NC 27611.

# TRAVEL IN THE TRIANGLE: CHOICES

## EXECUTIVE SUMMARY

Now is the time to move ahead with the planning and development of a public transportation system for the Research Triangle region. If city and county governments maintain the interest in and support for public transportation that this study has created, a regional system can be realized very soon. More importantly, continued planning and successful initial services will pave the way for a future public transportation network which will connect the corners of the Triangle.

As the first report in this series, Travel in the Triangle: Trends, has shown, five major highway corridors serve the Research Triangle region. Most of them are now experiencing severe traffic congestion during the rush hours. In 10 to 15 years all of these arteries will be experiencing traffic jams even with construction of additional lanes. Additional transportation capacity, beyond that which is currently planned, must be provided for the region to continue to grow without undue traffic impacts.

This additional capacity may be provided entirely by new highways. On the other hand, some people may maintain that public transportation is the answer. Realistically, however, both highways and public transportation are needed. A balanced system of regional highways and public transportation services will complement each other and provide increased mobility to the citizens of the region. Inter-city commuters, shoppers, and persons going to Triangle universities, hospitals, the airport, social services, or other locations will benefit.

Before major progress on a regional public transportation system can be made, however, four basic questions must be answered.

1. What role can public transportation play in the future development of the Triangle region?

2. Which types of public transportation are appropriate for the Research Triangle region?

3. To what extent can public transportation reduce the need for new highway construction?

4. What steps should be taken by leaders in the Research Triangle Area to develop a regional public transportation system?

Each of these questions is answered and briefly discussed in the paragraphs which follow.

What role can public transportation play in the future development of the Triangle region?

Public transportation has an important role to play Along with highways, as both can be catalysts for land use change. Over the years highways have allowed city boundaries to be pushed outward and helped create suburbs while maintaining access to jobs. Similarly public transportation can provide access to employment and other locations necessary for the health and welfare of our citizens and visitors. High capacity services like express buses or light rail can create a focus for clustered, high density development which can more productively shape urban forces which lead to urban sprawl and traffic congestion.

It is inappropriate, however, for public transportation or highways to be the driving forces which create, by default, the form of the cities in which we live. It is appropriate for community leaders to develop master plans for the Triangle region, so that transportation networks can be designed to serve the land use. In this process, care must be taken to preserve right-of-way for both highway and public transportation options so that they are not prematurely foreclosed. There has already been public discussion on the need to preserve highway right-of-way. Similarly, possible rail corridors, like the state-owned North Carolina Railroad connecting Raleigh, Cary, Morrisville, the Research Triangle Park, and Durham, should also be protected for possible future high capacity transit service and high density development.

What types of public transportation are appropriate for the Research Triangle region?

Public transportation includes a range of services. Ridesharing in carpools, vanpools, local buses, and express buses are familiar to most people. Commuter lanes that accept only high occupancy vehicles such as carpools, vanpools, and buses are common in many large metropolitan areas. Light rail service, which is a modern reincarnation of the old street trolley, is effectively used in a number of locations. In the largest cities metrorail (subways) and commuter trains are used. Trains on monorail track are also used in special high capacity situations like theme parks.

To determine which of these options are appropriate, guidelines for successful public transportation service may be compared to future trends in the Triangle region. Based on population, employment, residential and non-residential densities, and commuter demand, it has been determined that carpools, vanpools, express buses, and commuter lanes are most appropriate for commuter travel, at least in the I-40 corridor which was used as a case study in this analysis. The future traffic volumes in this corridor are similar to or less than those on I-40/NC-54 between Chapel Hill and the Park, US-70

between Raleigh and Durham, and US 15-501 between Chapel Hill and Durham. Thus, carpools, vanpools, and express buses, which can be complemented by commuter lanes, are appropriate public transportation options for those corridors as well. Other heavily traveled highways such as US-70 east of Raleigh, US-64 east and west of Raleigh, and I-85 into Durham were not studied but may warrant public transportation now or in the future. While this study concentrated on the use of public transportation for commuter travel, non-commuters would also use these public transportation for access to shopping, medical centers, entertainment, social services, and other purposes.

As metropolitan regions grow, high capacity, high speed rail alternatives become feasible and very desirable. Within the next 20 years the Triangle region may cross the threshold for which light rail is a workable option for commuter and other travel. Before this occurs, however, significant changes in land use and development trends must occur. Residential densities, at least in potential light rail corridors, would have to increase to an average of nine or more dwelling units per acre and generate demand equal to or greater than that on, for example, two lanes of I-40. Furthermore, employment densities would have to increase dramatically. Otherwise, many commuters would have to transfer from the light rail line to buses and vans to reach their final destination. Such transfers erode the travel time and convenience advantages created by light rail. This transfer problem at the employment end of the trip would be particularly acute in the Research Triangle Park and neighboring developments which emphasize low density, scattered employment locations.

Metrorail, commuter train, and monorail systems at their current level of technical development are not appropriate for the Triangle region now or in the foreseeable future. Traveler demand is inadequate, and cost is too great. However, if one is optimistic about the pace of new rail technology and economic growth in the region, rail costs may fall and commuter demand may increase sufficiently to warrant new consideration of emerging technologies like electromagnetically levitated, high speed trains.

<u>To what extent can public transportation reduce the need for new highway construction?</u>

If a relatively high percentage of persons choose public transportation for commuter and other trips, public transportation can help maintain acceptable levels of service on existing highways and their currently planned improvements. Properly operated and promoted, public transportation can forestall, but not eliminate, the long term need for new highway construction. Stated another way, public transportation can help stretch the value of our transportation dollar.

At present the average vehicle occupancy rate (VOR) in the morning rush hour on I-40 to the Research Triangle Park area is a

low 1.1 persons per vehicle. This translates to one person in addition to the driver in every tenth car. Highway corridors to major downtown employment centers often have a VOR of 1.3 or higher, especially when parking is restricted and travel costs for gasoline, parking, and tolls are expensive. If the present 1.1 VOR continues into the future, the currently planned six-lane I-40 will not carry the projected 1995 traffic. If traffic jam conditions are to be avoided, a VOR of 1.2 would have to be achieved. This means that the number of commuters sharing rides would have to double in the next ten years. Unfortunately the 1.2 rate is still low and would leave I-40 at about the same level of service (LOS E) that it is at today. Average VOR would have to reach 1.4 or better if all six lanes of I-40 are to operate at an acceptable level of service (LOS C) with moderate congestion.

In order to reach higher rates of vehicle occupancy, the attraction of ridesharing must be increased relative to the single passenger automobile. One way of achieving this is to build commuter lanes which, during rush hours, are open only to high occupancy vehicles like vanpools, buses, and carpools with three or more passengers. Because little or no congestion exists on a commuter lane, the travel time along the commuter lane is less than on the adjacent general traffic lanes. This travel time reduction is one type of incentive for ridesharing. Other incentives include special parking privileges, lower commuter costs, and the convenience of having someone else do the driving.

To explore the commuter lane option a bit further, suppose that commuter lanes were built on I-40 instead of the planned general traffic lanes. What would be the impact on, for example, 1995 traffic congestion, and would commuters use the special lanes?

If vehicles had to have three or more passengers in them to use a commuter lane, an excellent level of service (LOS B) traffic flow could be achieved. The trip to work along the 10-mile commuter lane would be faster and save commuters approximately three to five minutes relative to travel in the adjacent general lanes where traffic would move at an improved level of service (LOS D).

By building a commuter lane, travel would be significantly better for those who choose ridesharing, and for the commuters in private automobiles. Without a commuter lane and without increased ridesharing, the new six-lane I-40 will be over-capacity (LOS E) soon after it is opened between Raleigh and the Research Triangle Park. For successful commuter lane operation, the average VOR must be 1.4, which is a high, but reachable goal. Charlotte, for example, has a similar ridesharing goal for travel to the downtown area. With the synergistic, mutually beneficial interactions between a good regional ridesharing program and commuter lanes, the necessary VOR can be achieved.

Light rail service can also affect traffic congestion and the need to build highways if a high percentage of travelers use the system. Theoretically a high capacity light rail line can substitute for up to seven highway lanes in high density corridors. In lower capacity corridors light rail is usually justified for a ridership of 4000 passengers per hour which is equivalent to about two highway lanes. To assess feasibility of light rail transit this threshold ridership figure can be compared to projected regional travel. Such a comparison suggests a required light rail ridership of about 12% of the total commuters by the year 2005. If only the Durham Expressway corridor, which is one possible light rail route, is considered, approximately 36% of the commuters in that corridor would have to choose light rail for it to be feasible. Right-of-way, construction, and operating costs, as well as access and distribution problems must also be considered in evaluating the feasibility of light rail. If light rail becomes feasible in the future, it can make a significant impact on congestion and the need to build highway lanes. As discussed in the answer to the first major question, however, the outlook for light rail remains uncertain.

In summary, if there can be significant increases in the use of carpools, vanpools, buses, or light rail, then there can be significant impacts on congestion and the need to build highways. The success of public transportation, however, will depend not only on making it available, but also on making it attractive with respect to cost, convenience, speed, and safety. There are challenging opportunities to the public and private sectors to use transportation and land use policies to influence public transportation and eventually the ways in which we live and travel.

<u>What steps should be taken by leaders in the Research Triangle area to develop a regional public transportation system?</u>

Public transportation will be an important link in the regional transportation network of the future, and it can have an important role to play in determining land use patterns and development. It can not only carry many people to their jobs and other destinations, but it can also be the focus of desirable development in high density corridors. To achieve the optimum blend of highways, public transportation, and development, area leaders must continue their proactive, anticipatory roles in coordinated land use and transportation planning.

As this issue receives increasing attention from area leaders, citizens' groups, and the press, positive steps are being taken to use public transportation as an effective mode of regional transportation. A private operator has submitted a proposal for a small-scale, regional bus service to connect Raleigh, the airport, the Research Triangle Park, and Durham. The North Carolina Department of Transportation is studying the

feasibility of constructing high occupancy vehicle lanes on I-40 between Raleigh and the Research Triangle Park. One county is examining how funds from a transportation bond issue may be used to support regional efforts to coordinate public transportation. The governing bodies in each jurisdiction of the study area, the Airport Authority, the Raleigh Transit Authority, and the Research Triangle Park Owners and Tenants Association have discussed preliminary findings of the study. The Transportation Advisory Committees of the Raleigh/Cary and Chapel Hill/Durham areas are considering the regional public transportation options.

Such regional interest in public transportation issues needs to be nurtured. The concept of public transportation for the Triangle region is still in an incubation period. The findings of this report and its companion reports must be further examined and discussed before full-fledged public transportation service on a regional basis develops. Coordinated efforts for preliminary planning must continue. Additional efforts should be directed by a regional coordinating body, such as the Joint Transportation Advisory Committee, and supported by both local jurisdictions and the Department of Transportation. In this regard some very specific recommendations are offered with respect to public transportation.

1. Recognize that the Research Triangle region is becoming a metropolitan area and that public transportation needs, as well as highway needs, must be addressed on a regional basis.

2. Develop an organization to carry out regional public transportation planning and operation. Initial planning efforts could be coordinated through a subcommittee of the Joint Transportation Advisory Committee. This subcommittee could schedule, review, and call for action on the recommendations made in this report. Future planning and operations could be carried out through an independent group like a regional public transportation advisory group or authority.

3. Reconsider regional development goals and explore the feasibility of high density development along transportation corridors. Planners and elected officials should identify likely corridors for high density development. A new study should demonstrate how high density land use development and public transportation can be coordinated.

4. Emphasize carpooling and vanpooling through the existing regional TRI-A-Ride program. Ridesharing coordinators and representatives of area businesses should intensify their efforts to match riders in order to achieve higher vehicle occupancy rates. Related factors such as marketing and ridesharing incentives need to be considered in future studies.

5. Study the feasibility of implementing staggered work hours on a more widespread, coordinated basis in the I-40 corridor. Traffic count data in Report No. 1 dramatically shows that if the rush hour traffic peaks could be flattened by additional staggering of work hours, a significant improvement in congestion is possible.

6. Initiate regional bus service with a public or private operator. In conjunction with the planning for this service, conduct a marketing study to determine who will use the service, where it should be routed, and what it should cost.

7. Increase the number of park-and-ride lots to serve the expected increase in carpools, vanpools, and express buses. A study should identify potential locations along regional transportation corridors.

8. Preserve potential transportation corridors for light rail service, as well as highways, in order not to foreclose any future transportation possibilities. The identification of such corridors will result from the transportation corridor study called for in #3 above.

9. As preliminary planning progresses for new highway lanes in over-capacity corridors, continue to examine the feasibility of building commuter lanes instead of general traffic lanes. A study for I-40 between Raleigh and the Research Triangle Park is underway at the North Carolina Department of Transportation and will determine to what extent commuter lanes can decrease congestion for different levels of assumed vehicle occupancy. Further studies are needed to define how to achieve the indicated levels of ridesharing.

10. Depending on the outcome of preliminary planning studies, construct commuter lanes in the medians of I-40 between Raleigh and Chapel Hill, the Durham Freeway, and the Northern Wake Freeway.

11. Depending on future existence of high density corridor development and the pace of such development, examine the feasibility of a light rail system which connects downtown centers, residential and shopping clusters, and employment centers in the Triangle Region.

12. Depending on the feasibility of light rail service, design and construct a regional light rail system.

13. Evaluate new technological possibilities as they emerge.

The future will bring exciting opportunities to the Research Triangle Region. The challenge for regional leaders is to mold the opportunities into an attractive, livable environment. One key to success is for leaders to develop a future image for the region and use innovative land use and transportation solutions, including public transportation, to bring that image to reality.

# 1. INTRODUCTION

## Alternative Futures

Buffalo, Fort Worth, Hartford, Portland, Salt Lake City, and Louisville are metropolitan areas that have one common feature: a population of about one million. By the year 2000 -- only 14 years from now -- the Research Triangle region will be this large.

Indeed, the Triangle is growing. In population and jobs, the Triangle is quickly becoming a large metropolitan area. Unlike its counterparts elsewhere, the Triangle has not grown outward from a single central city but is growing inward from three nodes near its periphery. As the Research Triangle Park and surrounding areas develop, the region is virtually growing a new center. The result is a low density, dispersed collection of cities, towns, and industrial/office complexes that are rapidly becoming an integrated urban region.

The impacts of growth appear quickly. Even those who have lived in the Triangle just a few years notice what appear to be dramatic and sudden changes. Land that was farmland suddenly sprouts an office complex. A small house is replaced overnight by a fast food restaurant, and roads that once were rural become clogged. Change is not always pleasant, especially when it is sudden.

The development of the Triangle teaches us at least two lessons, both of which are discussed in the first report from the Research Triangle Area Public Transportation Study. One is that we cannot afford to solve the congestion problem by only building highways. Highway construction is clearly an important partial remedy; however, forecasts show that the major highway corridors will become ever more congested as growth surpasses our ability to build and finance highways. We need to do more than build highways.

The second lesson concerns timing. Just as the impacts of growth in the Triangle Area appear to be sudden, so too do we need to act quickly to prepare for the future. If there is a time to consider and prepare for alternative transportation remedies, the time is now. This urgency is particularly true with respect to fixed-guideway transit facilities, such as light rail. Even if these systems are not justified now, they may be in the future. It is therefore necessary to consider them now so that rights-of-way can be protected before development precludes transportation corridors that may be needed in a few years.

There is a close relationship between land development and the need for transportation services. Furthermore, the type of land development affects the choice of transportation service. This region has traditionally followed low density development policies which favor highways. More small but growing high den-

sity clusters of apartments, condominiums, and high-rise offices are being built. As development policies change and land use density rises, transit options will become more attractive.

The result is that we have a choice not only of transportation options, but also of development policies. Moreover, each choice affects the other. A policy choice which balances low and high density development with appropriate highway and public transit options will help the Triangle to continue to grow with a minimum of "big city" traffic problems.

Analytical Approach

The "chicken and egg" relationship between transportation and land use creates a problem in analyzing alternative transportation systems for the Triangle. How can the feasibility of a particular transportation option be assessed without first knowing what the development pattern will be?

We answer this question by working backward. The traffic projections in Report No. 1 assume that growth will occur as projected in the thoroughfare plans for the cities within this region. In testing the feasibility of a particular public transportation option, we can determine what minimum threshold residential and employment densities are needed for a particular option to be feasible and compare these with the densities forecasted in the thoroughfare plans. If the threshold densities are greater than the forecast densities, the options are not feasible. This approach could be extended to estimate what additional land use controls are necessary in order to make the option feasible. Thus, transportation option analysis could be translated into locally controlled zoning policy choices.

This report follows this density analysis approach and complements it with other indicators of successful service. First, a full range of transportation options are examined. Second, after the initial screening and with guidance from the technical advisory committee for this project, a reduced set of options are identified and analyzed in more detail. The selected options for analysis are: ridesharing; commuter lanes; regional express bus; light rail; and three systems for circulation within the Park. The analysis for these options includes examples of typical routes, potential demand, right-of-way availability, ease of implementation, speed, capacity, impact on congestion, and cost.

Each of the options is actually a family of options. For example, there are many configurations that a light rail system could have. Likewise, there are several highways to which a commuter lane could be added. To avoid the impossibility of analyzing each variation in these options, we instead examine representative variations. That is, we examine commuter lanes on only one highway (I-40) and only one possible light rail route (Raleigh to the Park). This use of representative options and the I-40 corridor means that the analysis is not a final de-

termination of feasibility but rather a first-cut analysis. We make only minimal assumptions regarding what is necessary in order for an option to be feasible. If it happens to be feasible in the I-40 corridor, and other corridors in the study area have similar travel and land use characteristics, then the option is likely to be feasible in those corridors also.

Light rail illustrates this approach. We used the lowest employment and residential densities from U.S. cities with light rail and assume that these values represent the threshold for light rail feasibility. The findings must be carefully interpreted. If the results show that an option is not feasible, then it clearly is not. If the results indicate that an option is feasible, however, then the results actually mean that the option warrants additional, more detailed analysis for demand, performance, and cost.

The next section discusses the full range of public transportation options that have been proposed at one time or another for this area and selects the ones that show promise. Commonly accepted guidelines and warrants for successful service are the basis for the selection. The remainder of the report presents the results of the more detailed feasibility analysis that was applied to the selected options.

## 2. SERVICE OPTIONS AND GUIDELINES

This section of the report examines the full range of public transportation services and tests for their applicability to the Triangle region. Using guidelines and warrants for successful service, a candidate set of options is identified for further feasibility analysis in subsequent sections of this report.

### Service Options

There is a wide spectrum of public transportation options with different service characteristics which may be suitable for the Triangle Region (Exhibit 1). At present there are public transportation services that include local bus service within city boundaries, some inter-city commuter bus service, and limited carpooling and vanpooling. Carpooling, vanpooling, and express bus are options that have proved to be viable and inexpensive options in other cities where they have reduced traffic congestion. Another potentially successful approach to making highways more efficient is the construction of dedicated commuter lanes in existing highway medians. Commuter lanes which permit only carpools, vanpools, and buses to use them are much more expensive than ridesharing programs. They cost at least as much as a new highway lane in existing right-of-way, and perhaps twice as much depending on interchange modifications.

Other options include light rail transit which is a modern version of the old street car; monorail like that at Epcot Center; and metrorail like that used in Washington, Atlanta, and elsewhere. In addition, it is possible that demand-responsive van service and other types of systems may also play a role in regional public transportation. All these options are considered in this report.

Options oriented to transportation system management such as lane restripping, signal coordination, flextime, and pricing strategies, while interesting, are beyond the scope of this study.

### Guidelines for Successful Service

Assuming technical and financial feasibility, adequate ridership is the determining factor for public transportation. For the Triangle area generating sufficient ridership to support a particular public transportation option depends on two basic parameters -- user convenience and user cost -- and how they compare with automobile transportation. Convenience can be measured by the accessibility of the rider to public transportation service and by the total travel time on the option including wait times and transfers. Cost depends on any fares, parking charges, or other "out-of-pocket" expenses. Thus, the complete prediction of ridership levels for a new service depends on careful modeling including competition from the automobile and alternative operating policies which affect the cost.

This level of analytical detail is not used directly in this study. Rather, a comparative analysis of guidelines for successful service elsewhere is used. For example, population is a fundamental, though rather general, guideline for indicating potential ridership and for matching public transportation options to communities. Exhibit 2 shows typical urban area populations required to support various services and typical volumes carried.

By the year 2005 the following changes are expected: Raleigh and Durham will each approach or exceed 250,000 population; total population for the Triangle area will exceed one million; and jobs in the I-40 corridor between Raleigh and the Chapel Hill-Durham area will grow to 100,000 (TJCOG, 1986 and NCDOT). According to Exhibit 2 in this report, all options are potential candidates on the basis of regional population and employment, but ridership and density guidelines must also be considered.

Monorail and metrorail, while meeting population guidelines, at least at the regional level, are not appropriate based on density guidelines in Exhibit 3 when compared to estimated area densities in Exhibit 4. It is projected that in the year 2005 the average urban area density for the Triangle area will be about three dwelling units per acre. Densities along some corridors will be somewhat higher. The commuter rail alternative appears justified on the basis of regional population and density projections, but they are only used for service to the largest downtowns where concentrated employment locations can provide not only commuter ridership, but also non-rush hour patronage to justify all-day service.

Thus, only carpooling, vanpooling, commuter lanes, and express bus service appear warranted. Expanded local bus service and light rail may be appropriate if relatively high density corridors develop.

Public Transportation Options

The most warranted options for expanded regional public transportation service are ridesharing by carpools or vanpools, and express bus. Light rail transit may be feasible if higher densities occur. Commuter lanes should also be considered in order to make more efficient use of highway capacity and to enhance the attractiveness of ridesharing and express bus by giving high occupancy vehicles preferential, higher speed service. Monorail, metrorail, and commuter rail fail to meet population, density, or other demand-related requirements.

Each of the options - carpooling, vanpooling, express bus, commuter lanes, and light rail - will be examined in more detail in the following sections. Internal circulation options for the Research Triangle Park will be addressed in this study by examining a demand responsive van service, a fixed route bus service, and a monorail system. These RTP circulation systems demonstrate approaches to the collection and distribution problems associated with line haul options like express bus and light rail.

EXHIBIT 1

CHARACTERISTICS OF PUBLIC TRANSPORTATION SERVICES

1. Carpools and vanpools. Transportation provided by carpools and vanpools is generally substantially better than bus transit in terms of access, door-to-door trip times, and comfort. Gasoline costs may be significantly reduced and poolers are relieved from the burden of driving through congested streets. Conventional transit and the private automobile have the distinct advantage of greater schedule flexibility, however.

2. Conventional transit. Conventional bus services operate mainly in urban areas on fixed routes and schedules. Service is available to all interested users.

3. Express bus. Service provided by express bus is limited to a single or few origins and a single or few destinations. This is a "line-haul" operation with few intervening stops. It occurs typically between outlying areas and points of employment concentration, such as suburb to central business district. Riders may drive to the origin, perhaps a "park-and-ride" lot, transfer to the bus, and ride it directly to their destination with few if any intervening stops.

4. Commuter lane. A commuter lane is an arterial or freeway lane which is dedicated to vehicles which have a specified occupancy, generally three or more riders. During the morning and evening rush hours only the higher occupancy vehicles are allowed to use the commuter lane. It reverts to general used at other times.

5. Light rail transit. Light rail transit (LRT) refers to electric rail operations with vehicles that are smaller and lighter weight than conventional rail or subway vehicles. The right-of-way may be exclusively for the LRT, but may also share streets as trolleys of another era did. Typical train size is two to four vehicles. LRT may be employed where medium radial corridor demand exists.

6. Heavy rail transit (commuter rail and metro/subway service). These options consist of heavy, high capacity, high speed transit trains of three to six cars servicing a dedicated rail route network. Such systems are used when significantly high corridor or radial demand density is well established over the long line lengths. The many stops and the very high cost is justified by ridership.

7. Monorail. Monorail systems are for the most part experimental or operate in theme parks. They operate on single rails with linear induction motors. As yet they are not used for long distance commuting.

8. Demand responsive service. Taxi service is the most common form of demand responsive service. However, van and bus service may also be demand responsive. Such service is characterized by individualized pickup of passengers and delivery to specific locations. It may be used where conventional transit service is not warranted because of low demand.

Exhibit 2

Threshold Population and Ridership Guidelines
For Implementing Public Transportation Options

| Option | Population | Ridership (passengers) |
|---|---|---|
| Carpool | any level | 2/vehicle |
| Vanpool | any level | 7/vehicle |
| Express Bus | 250,000 | 40/vehicle |
| Commuter Lane | (20,000 jobs) | 2000/hour |
| Light Rail | 200,000 | 4000/hour |
| Monorail | not available | 10,000/hour |
| Metrorail | 700,000 | 15,000/hour |
| Commuter Rail | 800,000 | 20,000/hour |

Source: Regional Plan Association

Exhibit 3

Threshold Density and other Guidelines for Implementing Public Transportation Options

| Option | Residential Density | Peak Hour Service | Remarks |
|---|---|---|---|
| Carpool | any level | Same neighborhood or P&R lot to same job location | Informally or formally organized |
| Vanpool | any level | Same neighborhood or P&R lot to same job location | Formally organized |
| Local Bus | 4-15 DU/acre | 2-12 buses/hour | To CBDs from residential areas |
| Express Bus (access by auto) | 3 DU/acre | 2-5 buses/hour (10-20 mile route) | To CBDs with at least 20M sq.ft. of contiguous business floorspace |
| Express Bus (access by foot) | 15 DU/acre (2 sq. mile area) | 2-3 buses/hour (10-15 mile route) | To largest CBDs only |
| Light Rail | 9 DU/acre (25-100 sq. mile corridor) | 10-20 trains/hour | To CBDs with 20-50M sq. ft. of contiguous business floorspace |
| Metrorail | 12 DU/acre (100-150 sq. mile corridor) | 10-20 trains/hour | To CBD's with at least 50M sq. ft. of nonreserved floorspace |
| Commuter Rail | 1-2 DU/acre | 20 trains/day | Only to largest CBDs if rail line exists |

Note: DU - Dwelling Unit
P&R- Park and Ride
CBD- Central Business District

Source: Regional Plan Association

Exhibit 4

Population Densities in the Triangle Area

| Jurisdiction | Population (1986) | Dwelling Units (1986) | Acres | DU/Acre |
|---|---|---|---|---|
| Counties: | | | | |
| Durham County (incl. Durham) | 166,800 | 68,000 | 191,360 | 0.36 |
| Orange County (incl. Ch. Hill) | 77,055 | 28,700 | 254,720 | 0.11 |
| Wake County (incl. Raleigh) | 379,598 | 149,157 | 552,960 | 0.27 |
| | 623,453 | 245,857 | 999,040 | 0.25 |
| Urban Areas | | | | |
| Durham | 119,025 | 47,500 | 29,710 | 1.60 |
| Chapel Hill | 36,709 | 12,313 | 9,277 | 1.33 |
| Carrboro | 11,170 | 5,445 | 1,740 | 3.14 |
| Raleigh (Inside Beltline) | 103,292 | 42,417 | 24,635 | 1.72 |
| Raleigh (total) | 203,290 | 80,396 | 51,218 | 1.57 |
| Cary | 38,079 | 14,549 | 20,559 | 0.71 |
| | 408,273 | 160,203 | 112,504 | 1.42 |

## 3. RIDESHARING

Ridesharing encompasses both carpools and vanpools. The section which follows describes both options.

### Carpools

Carpooling is a form of ridesharing in which two or more people share private automobile transportation on a regular basis. The ride matching arrangements may be informal or formally sponsored by a company or agency. Riders typically share operating costs and/or take turns driving the group.

At least two passengers are required to form a carpool. Any size urban area may contain a significant number of carpools depending on the length and cost of daily commutes. Heavy carpool use does not occur, however, without a good marketing program coupled with complementary policies affecting parking charges, parking privileges, commuter lanes, or other incentives to share rides.

Carpooling is used in the Triangle region since traffic counts indicate that one automobile in ten travelling to the Research Triangle Park has more than one occupant in it (Wilbur Smith, 1985). Assuming only two people in the carpool, the average vehicle occupancy rate is 1.1 persons per vehicle. This rate is typical of commuters unless parking restraints, gas prices, commuter lanes, or other factors make ridesharing more attractive. In the 1970's when gasoline costs were high, Raleigh traffic counts in the downtown area indicated average vehicle occupancy rates on the order of 1.3, however, that has recently decreased to about 1.1.

If one vehicle in ten is a carpool and if the carpool has only two people in it, then 18 percent of the riders share rides, and traffic congestion is thereby reduced by nine percent compared to what it would be if everyone drove alone to work. If the carpools averaged three riders each, the equivalent ridesharing would be 25 percent and congestion would be reduced by 17 percent. Thus, carpooling, through its effect on average auto occupancy, can make a significant impact on congestion.

Since carpooling is often based on informal ridesharing with personal automobiles, there is relatively little cost compared to formal ridesharing programs with vans or buses. Public agency and corporate sponsored programs for regional ridesharing have capital and operating costs that must be covered by rider fares, and they have administrative costs if one or two people are required to run the program.

Carpools often operate in highway traffic and are able to maintain the same speeds as single-passenger automobiles. Speed advantages occur if commuter lanes are available for the carpools and if heavy congestion is present in the remaining general traf-

fic lanes. Travel time can be lengthened, however, by the pickup and delivery time of passengers. Thus, carpoolers should live along a fairly direct route to the same destination, and they should also have similar work hours (Vuchic, 1981).

Vanpools

While carpools may accommodate up to four or five people, vanpools carry from six to 15 people. Riders share costs based on the distance of their individual commutes and on the number of people in the van. The higher the number of riders the lower the cost per rider. Usually the driver's share is paid by the group. As an incentive for forming the pool and maintaining the van, the driver may have limited personal use of the van.

The minimum number of passengers required for a self-supporting vanpool is usually about 12. Vanpools operate successfully in a variety of city sizes; however, success depends less on city size than on travel cost, travel time, and parking availability. Most successful vanpools operate over round-trip distances of 30 miles or more. Vans offer the advantages of low cost, flexible routes that may be modified as necessary to meet demand, and point-to-point service that minimizes distribution problems. In addition, they use the existing right-of-way of roads and highways. Unless commuter lanes are available, they suffer the same congestion delays as automobiles.

This area has had modest success with formal vanpool services for commuters. In late 1986 seven vanpools were being operated by the Triangle J Council of Governments Tri-A-Ride program. Twenty-four vans were being operated by corporate programs and of these 10 were in the Research Triangle Park. Modest expansion is being planned by Tri-A-Ride and one of the corporate programs.

The remainder of this section concentrates on the operating characteristics, costs, and benefits of an example vanpool program.

Ridesharing Scenario

Ridesharing programs mix carpooling and vanpooling. For moderate sized areas such as the Triangle they represent the most financially feasible services as well as providing excellent improvements in the passenger-carrying capacity of existing facilities.

This analysis assumes that carpools will continue to form through informal arrangements as well as through formal rider matching programs. Persons sharing carpools will be picked up at their homes or at central meeting points such as park-and-ride lots. It will be assumed that vanpools are formed under more formal matching programs and operate from a park-and-ride lot at Carter-Finley Stadium to destinations within the Research

Triangle Park. Vans may also pick up riders on the way to the stadium lot as do carpools. Carpools and vanpools serve no more than one or two employment locations. The a.m. peak hour is used for the analysis, and the two ridesharing options operate along an I-40 route that could have a commuter lane. The commuter lane could also carry express buses and carpools.

This analysis illustrates what can be done with a combined carpool and vanpool program in one corridor. For regional results, the analysis should be repeated in other commuting corridors, such as routes NC 54, US 70, and US 15-501.

Potential Demand for Ridesharing

In many U.S. cities a transit ridership between five and six percent is typical, and on heavily patronized systems the transit ridership may approach 30 to 40 percent. This analysis will use these figures as a guide for ridesharing by carpools and vanpools. Thus, if approximately 7000 morning rush hour commuters travel the I-40 link from Raleigh to the Research Triangle Park in 2005 (Report No. 1, Exhibit 6), then potentially five to 30 percent of them or 450 to 2500 commuters per hour would choose ridesharing if it were available. For this range of ridership about 40 to 200 15-passenger vans would be required (assuming 12 passengers per van) depending on the carpool-vanpool proportion of commuters.

Right-of-Way and Facility Requirements

Carpools and vanpools use existing road networks, and no new right-of-way is required. If commuter lanes were built along I-40 to complement carpools, vanpools, and bus options, they could be placed in the existing median. New land may have to be purchased or leased for park-and-ride lots, however, park-and-ride lots are often located at churches, shopping centers, and athletic facilities for little or no charge. Since cars and vans can be stored at the drivers' residence and maintenance can be performed at existing service stations, no storage or maintenance facilities are necessary except for parking space during normal working hours.

Ease of Implementation

Financial support for vanpool operations and carpool matching programs is available from the North Carolina Department of Transportation and USDOT through grants for capital and administrative costs. Operating subsidies are not available. If they were available for vanpools as they are for public bus operations, vanpooling would be more financially competitive with the automobile. The recent increases in liability insurance may seriously affect financial feasibility of vanpools unless new insurance policies are formulated. Liability for carpools has not been a problem since passengers do not typically pay and are covered under the drivers' personal policies.

## Impact on Congestion and the Need for New Highway Construction

Currently the two west-bound lanes of I-40 carry about 3800 vehicles per hour which represents heavy, level of service D congestion. At times traffic may come to a near stop as it approaches capacity at level of service E. In order to demonstrate the effect a vanpool and carpool matching program could have on congestion, consider the year 2005 forecast of 7,000 rush hour vehicles traveling on I-40 from Raleigh to the Research Triangle area (Report No. 1, Exhibit 6).

This level of traffic is approximately 900 vehicles per hour greater than three-lane capacity defined at level of service D, which represents dense but freely flowing traffic. Assuming that the average auto occupancy remains 1.1 persons per vehicle as it is in 1986, then 990 "excess" commuters will travel the route in 2005. If they all transferred to a vanpool program, there would be a 13 percent modal split increase above the current 18 percent related to carpools. This 31 percent modal split is an achievable, though difficult, objective. If 83 vans are used, assuming an average occupancy of 12 riders, the "over-capacity vehicles" will be reduced from 900 to 83. This represents a 72 percent decrease in "over-capacity" traffic volume, and a 10 percent decrease in overall traffic. With the combined 31 percent mode split from carpooling and vanpooling, the three lanes would operate at level of service D which is an acceptable level according to area transportation planners.

If a commuter lane were built from Raleigh to the Research Triangle Park instead of a third general lane as assumed above, then, from Exhibit 6 in Report No. 1, approximately 2900 vehicles per hour in excess of two-lane capacity would be travelling in the corridor. The 2900 vehicles represent 3200 commuters assuming an occupancy rate of 1.1. If, for example, all these commuters elected to take vanpools a 41 percent modal split would occur, and the required vans would number 266. If the commuters all chose carpools that carried three persons per car, the vehicles would number about 1,000. In either case, the carpools and vanpools, or any combination of them, could easily be accommodated by the commuter lane. The remaining two general lanes would operate at level of service D as they currently do. A modal split of 41 percent, however, is unlikely, and a fourth westbound lane or a parallel facility in an adjacent corridor appears to be eventually warranted regardless of the availability of alternative transportation modes.

Any combination of vanpools and carpools that gives a mode split as high as 41 percent is not likely to replace the need for new highway construction. If vanpools and carpools are sufficiently convenient, inexpensive, fast, safe, and comfortable to enable them to compete with the private automobile, they may provide about a 30 percent mode split which translates to an equivalent of about a half a lane of capacity.

Costs

Since vehicles in carpools are usually private autos, and the trading of rides substitutes for fares, there are no capital or operating cost associated with carpools. Some administrative costs may be allocated to carpools on a regional basis if there are ride matching programs.

Initial capital costs for a vanpool are usually supported by a sponsoring agency, but are later recovered from user fees. Depending on the accessories added to the van, the cost may be $20,000 or more. For a range of potential demand equivalent to a mode split of five to 30 percent, 40 to 200 vans costing $800,000 to $4.0 million would be required. This range of costs does not include complementary actions such as parking incentives and commuter lane construction. Operating costs are usually handled by the driver using rider fees. Special maintenance facilities are not required since maintenance is usually conducted through existing community businesses.

For the Triangle Area, the cost of operating a van for a daily 30-mile round trip is about $400 per month or $4800 per year according to Triangle-J COG estimates (September, 1986). For an average of 12 passengers per van this amounts to $33 per month per rider. This is less than the $40 "out-of-pocket" gasoline cost if the commuter were to drive his or her own private automobile over the same route. This comparison assumes a gasoline cost of $1.00 per gallon, gasoline consumption at the rate of 15 miles per gallon, and no cost for parking. If depreciation and maintenance costs for the private automobile are also included in the comparison, the vanpool represents significant financial savings to the commuter. Unless the "second" family automobile can be sold, however, depreciation and maintenance costs should not be included in the comparison.

If the commuter were to carpool with at least one other person, the private auto out-of-pocket costs fall to $20 per month, or less if gas prices are lower than the $1.00 per gallon, and if gasoline mileage is higher than 15 miles per gallon as assumed above. The carpool may then become more financially attractive than the vanpool.

For the vanpool to appear more attractive on a dollar basis, gasoline prices would have to increase or parking or other fees would have to be instituted at the place of employment. Alternatively, new and innovative means of subsidizing vanpool costs could be found. For local bus operations up to 50 percent of operating costs are subsidized by the federal government, and nearly all capital costs are paid for by a combination of federal, state, and local assistance. The possibility of similar subsidies for vanpools and other ridesharing modes is a policy option. At present only the startup capital costs of a vanpool are subsidized. Replacement and maintenance costs are covered by user fees.

In order to derive a system operating cost for comparison purposes it will be assumed that each of 12 passengers per van would pay $400 per year to cover all operating costs. This does not include the operation of a regional vanpool coordinating agency. For the range of service discussed above, the 40 to 200 vans would cost about $190,000 to $1 million per year to operate. These costs would be borne by the vanpool riders unless innovative subsidies were created.

Summary

Currently carpools and vanpools are used at a fairly low rate in the Triangle Area, but their use will increase if there are clear advantages in travel time and cost over the private automobile. Elsewhere they have proven particularly successful under special circumstances, such as high gasoline or parking costs. Travel time advantages can be obtained with concurrent use of commuter lanes. Cost savings to the commuter will occur if van operating costs are subsidized or if parking charges are instituted at employment locations. Capital and operating costs are shared by users, and implementation procedures are relatively easy. Ridesharing by carpools and vanpools has the potential to reduce vehicular traffic from five to 30 percent.

# 4. EXPRESS BUS SERVICE

## General Description

Express buses operate like conventional buses but with fewer stops. The fastest service has only one pickup point and one destination. Local examples currently operate between Raleigh and Cary, Raleigh and Garner, and between the Wakefield Apartments in North Raleigh and North Carolina State University. Present and future residential and employment densities in the Triangle Area warrant express bus service, especially if the service is marketed to clusters of residential developments and large employers or activity centers. Express bus service can provide economical, safe and comfortable transportation at speeds comparable to the private automobile, especially if commuter express lanes are available for the non-stop portion of the trip. During the non-stop portion of the trip in a commuter lane, express buses travel up to twice as fast as vehicles in adjacent standard lanes. For the total trip, however, passenger access time and wait time will tend to erode, if not exceed, the travel time advantage that a commuter lane gives to express buses.

## An Example of an Express Bus Service

A minimum of seven miles is recommended for operating an express bus line (UMTA, 1978). This route length can be achieved from Raleigh to RTP, Chapel Hill to RTP, and from points north of Durham (Treyburn) to RTP.

In order to compare express bus service to other public transportation alternatives in this report, we assume that the service exists from Raleigh to the Research Triangle Area and utilizes the I-40 corridor. Each express bus route would originate at a park-and-ride lot or local transit transfer point, and would make one or two stops such as at the Airport, the Park, or a major employer before continuing on to a destination in Chapel Hill or Durham.

One possible route might originate from a park-and-ride lot at Carter-Finley Stadium and proceed to the Research Triangle Institute, via Blue Ridge Road, Wade Avenue, I-40, Davis Drive and Cornwallis Road. This segment of the sample route is approximately 14 miles long. The bus would continue to Chapel Hill or Durham after making one or two other Research Triangle Park area stops. Other routes might originate in Raleigh, Cary, Chapel Hill, and Durham and "criss-cross" in the Research Triangle Park and neighboring employment centers like the Airport.

## Potential Demand for Express Bus

Express buses must provide advantages over driving a car to work. Reduced travel time, lower cost, and less stress are potential advantages to riding a bus. If the overall travel time

for a bus trip compares to, or is less than that of a similar automobile trip, then some commuters will perceive an advantage. Complementary actions such as park-and-ride lots, commuter lanes, front door drop-off, and automobile parking charges can add to the attractiveness of express bus service. Implementation of express bus service without provision of adequate complementary actions cannot be expected to generate maximum ridership.

While this report concentrates on commuter travel, it should also be mentioned that regional bus service can provide important mid-day service to shoppers, students who travel between Triangle universities, airport passengers, UNC and Duke hospital patients, visitors to the region, and others. Such mid-day demand, however, is not included in the following estimates.

A "what if" analysis provides estimates of potential demand. Careful market analysis would be required to locate riders and match the express bus service to their destinations. If 10 routes could be identified it would be reasonable to assume there would be two routes each from Raleigh, Chapel Hill, Durham, Cary, and one other community or suburb. If the average capacity of these buses was 40 passengers each, then 400 regional commuters would be served during the rush hour. If the two buses from Raleigh start at Carter-Finley Stadium and travel along I-40 during the rush hour, carry 80 passengers, a 1.0 percent modal split (percentage of express bus ridership compared to total person-trips) for the I-40 corridor would occur based on year 2005 forecasts (Report No. 1, Exhibit 6).

Given sufficient demand, express bus service can easily be increased in frequency. An upper bound for ridership between Raleigh and the Research Triangle Park is defined by express buses operating one and a half minutes apart on a dedicated express bus lane. In this case as many as 40 buses could operate in a corridor like I-40 and carry as many as 2000 rush hour commuters. This level of ridership would represent a 26 percent modal split in the year 2005 for northbound I-40 traffic.

Right-of-Way and Facility Requirements

Express buses use existing roadways, so the only additional land required would be for transfer centers and park-and-ride lots. If a commuter lane were built, right-of-way may be available in existing highway medians. Maintenance facilities would not have to be built since there are at least six facilities in the Triangle Area.

Ease of Implementation

Implementation of express bus service is further facilitated since there is no fixed-guideway construction and service is provided on existing facilities. Also, express bus routing and scheduling are flexible allowing quick system start-up and easy modification in the future. Another important aspect of express

bus service is that it can be operated by either a public agency, by or a private provider. Depending on local and state regulations and costs, either public or private operation may be chosen.

Impact on Congestion and the Need for New Highway Construction

A hypothetical express bus service would reduce congestion and the need for new highway construction in the same manner as vanpooling and carpooling which were discussed in the previous section. Assuming there are three westbound I-40 lanes, acceptable level of service D operation requires a 13 percent modal shift by the year 2005. The 990 "over-capacity" commuters could be carried by 25 buses. This represents an achievable 13 percent gain in ridesharing in addition to the current 18 percent from carpooling for a total of 31 percent by ridesharing. If express bus service were to carry all ridesharing commuters, i.e., no carpools or vanpools operate, level of service D operation would be possible at 28 percent modal split because the buses make more efficient use of the roadway than the lower capacity carpools.

The above calculations assume that there are three general lanes and all traffic including carpools and express buses are free to use any lane. If, however, an express-bus-only commuter lane instead of a third general lane were built, there would be approximately 3600 over-capacity commuters instead of 990 if level of service D were to be maintained in the two general traffic lanes. A modal split of 47 percent representing the 3600 commuters on 90 buses would be necessary. This high a mode split is unlikely, and congestion would be unacceptable in the original two lanes unless new facilities in addition to the commuter lane were built in a parallel corridor like that for the Cary-Durham expressway. Note again, however, that a combination of public transportation options are likely to provide service, not just one.

Costs

Capital and operating costs are based on the sample route described above which connects Raleigh to the Research Triangle Park via I-40. These costs are assumed to represent typical route costs for other regional express buses.

Capital costs only include the purchase price of the buses. Maintenance facility costs are not included because it is assumed that maintenance occurs at existing facilities. Auxiliary facilities like bus stops are assumed to be negligible compared to the cost of the buses. For the 10 buses assumed for the hypothetical system, at a purchase price of about $160,000 per bus (1985 dollars, CUTS 1985), the total capital cost would be $1.6 million. For the I-40, Raleigh to RTP service, two buses costing $320,000 would be needed. Initial investment costs could be reduced significantly if the vehicles are leased until the

service proves successful, or if the usual 90 percent federal plus state subsidy is applied.

Operating cost estimates are based on an assumed $27 cost per vehicle hour (1985 dollars, CUTS 1985). Assuming service is provided at least four hours each day during the morning and evening rush periods, the annual operating cost comes to $281,000 for the 10-bus system and $56,000 for the two-bus, Raleigh-to-RTP route. If more buses operate or additional service is provided during the off-peak periods to shopping centers, the Airport, or hospitals, then the net annual operating costs increase.

Summary

Express buses can offer high capacity commuter and all-day service. Both commuters and non-commuters can be carried throughout the region. Buses can be professionally operated by either a public or private agency relying on informal organizations or volunteer drivers as do carpools and vanpools. The management expertise and facilities are available now for low to moderate levels of service which can be expanded as necessary if demand increases. Express bus service is moderately easy to implement, although a good market analysis is needed before operations planning can begin. The services should connect clustered centers of demand with employment locations and major activity centers. Provision should be made for easy access and transfer between existing local bus systems to minimize travel time. Access to express bus services may be from park-and-ride lots or from local bus routes.

At very high mode splits (50 percent private auto, 50 percent bus) express buses have the capability to reduce traffic congestion and reduce the need for new highway facilities in adjacent corridors. More likely mode splits are 30 percent and lower and will be accomplished by a combination of carpooling, vanpooling, and express bus.

## 5. COMMUTER LANES

### General Description

Commuter lanes are highway lanes which give exclusive peak hour use to high occupancy vehicles like carpools, vanpools, and buses. They represent a particularly important complementary action to ridesharing options because travel time can be reduced significantly, thereby attracting more commuters and reducing congestion. The lanes may be physically separated from the general traffic lanes by barriers, or they may be identified by special signs and pavement markings such as diamonds.

Commuter lanes are generally found in big cities like Washington, Chicago, and Los Angeles that have heavy traffic flows along expressway corridors. Commuter lanes are often used as to gain increased passenger-carrying capacity out of existing right-of-way when new construction opportunities are limited or nonexistent. They may be an attractive option for the growing employment base centered around the Research Triangle Park. Commuter lanes, however, typically serve dense downtowns, not low density areas like the Park and its neighbors. The more dense the development, the more appropriate public transportation service becomes. The more public transportation is used, the more feasible commuter lanes are.

### An Example of a Commuter Lane Location

Commuter lanes should be a minimum of three miles long. Recommended lengths are from five to ten miles (NYDOT, 1985). The recommended length requirement can be met between the major residential areas of Raleigh, Durham, Chapel Hill, and the employment locations in the Research Triangle Park area.

The I-40 corridor from Raleigh to RTP is chosen as a potential route based on current and projected demand volumes, route length, and the availability of right-of-way. An alignment consisting of an additional attached lane in each direction within the existing median is considered to be the most feasible route. No physical barrier is provided in order to reduce construction costs, to minimize weaving problems, and to maintain the flexibility to revert to general lane usage.

The commuter lane would begin at the Wade Avenue interchange and end at the Durham Expressway interchange. Additional access would have to be provided at the Davis Drive interchange. In this example the route is 9.9 miles long in both directions. It may be extended on I-40 to Chapel Hill and Hillsborough, on the Durham expressway to Durham, on I-40 south of Raleigh, and on the Northern Wake Expressway as traffic conditions and ridesharing volumes warrant.

## Right-of-Way and Facility Requirements

Commuter lanes can be located within existing right-of-way on I-40 and the Durham Expressway. Additional right-of-way may have to be provided for access at interchanges or other locations. Right-of-way requirements depend on the route alignment but it appears that the I-40 corridor generally contains sufficient right-of-way for commuter lanes. Similar median space is available on the plans for the Northern Wake Expressway. Depending on the route, new bridges or major modifications will be necessary. Park-and-ride lots should be coordinated with commuter lane construction and public transportation services.

## Demand Requirements for Commuter Lanes

In order to be justified, a commuter lane must carry almost as many people as an adjacent general traffic lane. Otherwise, the overall level of service of the highway will be reduced. For a three-lane highway this means that the commuter lane should carry about one-third of the people. This translates to an average vehicle occupancy of about 1.30 persons. Typical average vehicle occupancies for corridors leading into large employment areas may be as high as 1.30 to 1.35 persons per auto (NCHRP 187, 1978). Current auto occupancy in the Research Triangle area is about 1.1. This rather low value results from the lack of regional public transportation, development patterns which favor highway travel, and the personal preferences of commuters. Thus, in order to justify commuter lanes for the Triangle region, the average vehicle occupancy will have to be significantly increased.

Reaching the necessary level of vehicle occupancy requires about 2000 commuters to switch to ridesharing. This number of commuters could be carried by 660 three-person carpools, 500 four-person carpools, or 50 express buses traveling at the speed limit. Adjacent general traffic lanes would be at the capacity level of about 1800 to 2000 vehicles moving at 35 to 40 miles per hour with occasional traffic jams. Recall from the previous section of this report, however, that the highway configuration which includes two general traffic lanes and one commuter lane will not adequately carry the year 2005 traffic. About 1300 commuters or 1400 vehicles will have to divert to adjacent facilities.

If the average vehicle occupancy rate approaches 1.3 persons per vehicle, the commuter lane would be justified according to technical warrants for commuter lanes (NYDOT, 1985). If the occupancy rate falls below about 1.25, it is more advantageous from the standpoint of total capacity to convert the commuter lane to another general highway lane. Some communities, however, maintain commuter lanes at lower modal splits than these guidelines in order to promote public transportation and to meet other objectives, like reducing parking requirements and

congestion in downtown areas where commuter lanes usually terminate.

Travel Time on Commuter Lanes

In determining the potential demand for commuter lanes, it is important to note that demand is a function of perceived utility, that is, the advantage of commuter lanes over general lanes or of ridesharing over driving alone. To maintain a utility advantage and keep modal splits and demand high, a significant savings in travel time (typically on the order of one minute per mile of commuter lane length) must occur to offset the time lost in collecting and distributing passengers at either end of the trip on the commuter lane.

Depending on their length commuter lanes can greatly reduce travel time to work because they have little or no congestion compared to adjacent traffic lanes. For example, if traffic is moving at 30 miles per hour in the general lanes and at 60 miles per hour in the commuter lanes, one minute per mile in travel time is saved by using the commuter lane. Such a time saving may technically warrant the construction of a commuter lane (NYDOT, 1985).

For the example nine-mile commuter lane along I-40 as much as nine minutes could be saved if general traffic were congested at level of service D or worse. At these conditions there would be volumes in excess of 1,800 vehicles per lane and speeds of approximately 30 to 40 miles per hour. Operations on I-40 currently approach and sometimes exceed these conditions during the rush hour. Congestion will be worse in the future as more more cars attempt to use the facility.

Ease of Implementation

Implementation of commuter lanes for the route from Raleigh to RTP will encounter some difficulties. First, access to and from the commuter lanes may prove difficult. The proposed starting point is at Wade Avenue where much weaving occurs. The terminal point at Davis Drive presents additional weaving problems and interchange capacity problems. Second, the proposed lanes will likely be attached to the existing facility with no physical separation, such as a median or barrier walls. Otherwise, cost would be excessive and the option of converting the commuter lane to a general traffic lane would be lost. Without physical separation the violation rate is likely to be high (NYDOT, 1985). Enforcement will reduce violation rates but will substantially increase operating costs.

The third problem is utilization of the additional lane as a reserved priority lane. It is unlikely that enough commuters will switch to high-occupancy vehicles for the additional lane to carry as many person-trips as each of the general lanes. As discussed above about 30 percent of the commuters would have to

switch to ridesharing. Creating enough additional demand for ridesharing to support a commuter lane will be difficult without the commuter lane already being in place. This is the classic "chicken and egg" problem. Which should come first, the demand or the commuter lane? Strong public transportation marketing and complementary actions parking and other pricing actions may have to be considered to induce more ridesharing. As development increases along the corridor, the commuter lane will become more and more justified.

The fourth problem relates to the impact of the commuter lane on congestion. Unless additional parallel highway facilities are built, by the year 2005 all projected traffic will not able to be carried by a commuter lane and two general traffic lanes. Three general lanes may be sufficient, however, if there is a high percentage of ridesharing. Without the commuter lane, the travel time advantage is lost, and the incentive for ridesharing is lost.

Impact on Congestion and the Need for Highway Construction

Exhibit 6 of Report No. 1 shows that in the year 2005 the I-40 westbound traffic is greater than level of service D capacity with a volume of 7000 vehicles per hour at the morning peak. Over-capacity conditions occur even with three lanes open westbound. What happens if a commuter lane is built instead of a third general lane?

If the average auto occupancy is 1.1 persons, then 7700 persons per hour will travel northbound in the corridor in 2005. If a commuter lane is built and the modal split is 33%, then 2541 northbound commuters will use it. Assuming that they ride in carpools with an average occupancy of three persons per car, there will be 847 vehicles per hour in the commuter lane moving at 55 to 60 miles per hour. This level of traffic and speed represents level of service B traffic conditions (1965 HCM, Table 9.1). The remaining 4690 vehicles would be split between the two general lanes. If there were two lanes, they would be over-capacity at level of service E. At best traffic would move at speeds of 30 to 35 miles per hour and there would be relatively frequent traffic jam conditions. The difference in speed between the traffic in the general lanes and the commuter lane would be about one minute per mile, or about 10 minutes over the route. This type of time savings is often used to justify commuter lanes.

If there is only room in the right-of-way for one more lane, it would appear that the commuter lane is the best option for the third lane. At least one lane would be moving at acceptable, better than level of service D conditions, and it may attract many additional commuters to ridesharing. Additional facilities in parallel corridors also appear to be needed. If the Cary-Durham Parkway or Davis Drive Extended is built by 2005, the

over-capacity conditions on the I-40 general lanes would likely be rectified.

## Costs

Costs are based on the I-40 commuter lane route from Raleigh to RTP . Construction is the major capital cost element for the proposed commuter lane route. The cost of adding one additional lane in each direction within the existing median is estimated to be $10,000,000 (NCDOT, 1986). This result is based on a route length of 9.9 miles and assumes an average cost of $0.5 million per lane mile. Interchange improvements to for access to and from the commuter lane would cost about $5 million per interchange and be needed at least at the Wade Avenue and Davis Drive locations. The total cost would approach $20 million or more. The only operating cost for the proposed facility is for maintenance and is estimated to be $113,500 per year (CUTS, 1985).

## Summary

Commuter lanes are an important but expensive complement to ridesharing. By reducing the nonstop travel time of a carpool, vanpool, or bus trip by 50 percent, travel time losses from waiting and transfer may be recovered. The route between Raleigh and RTP offers an opportunity to test the commuter lane concept with the flexibility to convert it to a needed general traffic lane if the ridesharing demand fails to materialize. If the difficulties in justifying and building a commuter lane can be overcome, the commuter lane can have long term benefits. People will want to use a high quality, fast travel alternative and will locate their housing and employment to take advantage of the commuter lane.

## 6. LIGHT RAIL TRANSIT

### General Description

Light rail transit (LRT) utilizes electrically powered, light weight rail cars on fixed guideways. LRT is a technically sophisticated descendent of the trolleys that were prevalent throughout America up to the 1940's. The option is receiving renewed interest as a relatively low cost, high capacity alternative to highway construction in heavily travelled corridors especially where the rail right-of-way already exists.

LRT can be developed in stages. Beginning with a low volume, trolley-like system an LRT network can be expanded and new equipment added to create an express transport system. Each stage along the way to an express system may be complete in itself, but should make it possible for development to continue to the next higher stage.

At present there are about 100 LRT systems operating in cities worldwide of which 15 operate in US cities including Boston, Buffalo, Cleveland, New Orleans, San Diego, and San Jose. Additional systems are planned for Columbus, Dallas, Detroit, Los Angeles, Rochester, and Salt Lake City.

Most riders find LRT more attractive, faster, and comfortable than bus or van service. It has the best ride quality, and its image is highest among the transit modes.

### Land Use Characteristics for Successful LRT Operation

LRT systems are especially effective where the population at the origin end of the LRT line is at least 200,000, residential density is at least nine dwelling units per acre, and employment destinations have at least 20 million square feet of contiguous floor space (APTA, 1981). Such development would have to produce about 4000 passengers per hour to justify LRT (Vuchic, 1975). While the Triangle area meets the population threshold for LRT service, it fails the residential and employment density guidelines. Current development in this area is too dispersed for light rail operations. Future land use patterns, however, may change and justify LRT.

Consider, for example, that there are more and more high density residential development, new shopping areas, and high-rise office parks being built in the Triangle Area. Suppose that development could be clustered in transportation corridors served by light rail or other rail alternatives. What character would that development have to be in order to satisfy the above density guidelines, and is that type of development feasible in this area?

To explore these questions assume the following land use description for a potential light rail corridor between Raleigh and Durham:

a. Residential density in the corridor equals nine dwelling units per acre;

b. 1.5 employed persons live in each dwelling unit;

c. One-tenth of the residents along the corridor have direct LRT access to their jobs; and

d. The residents live in high density clusters which are one-half mile on each side so that the residents will have easy access to the LRT line.

With these parameters each of the clustered developments will generate about 200 potential LRT riders. If the rush hour is two hours long and approximately 4000 riders per hour are required to support a LRT line, then about 40 such clustered developments along the rail corridor are necessary. If the rail line stretches from the center of Raleigh to the center of Durham through the Research Triangle Park for a distance of approximately 30 miles, then about one development per mile is necessary. Such development would be difficult to achieve given current low density land-use development trends. Furthermore, much of the land along potential rights-of-way is already developed at lower densities or is reserved for state park, university, and Research Triangle Park use. Without such development the light rail service would not be justified.

Variations on the above result which are more favorable to light rail occur for higher development densities, higher ratios of riders headed to the Triangle Area from the clustered developments, and when park-and-ride or feeder transit services provide portions of the LRT demand from lower density areas. Also, other corridors may be identified as being more developable than the example used.

## An Example of a Light Rail Service

A 17-mile route using the North Carolina Railroad from Raleigh to RTP is used as an example route to facilitate comparison with other alternatives. Other factors influencing the selection of this route include state ownership of the railway right-of-way and the route's ability to serve Raleigh, Cary and Morrisville, and whether there are feeder transit services. The route could be extended to Durham along the same rail alignment, and connections to Chapel Hill, the developing US 70 corridor, and North Raleigh could be made along existing highway rights-of-way. Spurs or other ground connections would be needed for the Raleigh-Durham Airport and other major activity centers.

Depending on station spacing and the amount of grade-separated tracks, an LRT system can operate over the line haul portion of the route at speeds equal to or faster than the automobile (Vigrass, 1975). Total travel time, however, has to include access time to the LRT line and distribution time at the destination. The LRT route being considered will not be capable of directly carrying passengers to more than a few major employers within the Research Triangle Park. Supporting transit service using buses, vans, or peoplemovers would be required for distribution to other employers. The following section of this report examines such options.

The capacity of an LRT line is determined by the maximum number of cars operating per hour. Two-car trains could leave as often as once every minute. Typical cars have an average seated plus standing capacity of 75 passengers (CUTS, 1985). Thus, for a route with two-car trains, the capacity is a multiple of 150 and the number of departures per hour. With two-car trains and service every minute, the example route can accommodate 9360 passengers per hour. This LRT line capacity is equivalent to more than eight freeway lanes. Depending on the number of cars per train and the frequency of service, typical capacities may range from 1200 to 14000 passengers per hour.

Right-of-Way and Facility Requirements

The proposed right-of-way from Raleigh to Durham through the Research Triangle Park, Cary, and Morrisville is owned by the State of North Carolina. It is currently leased and used by Norfolk-Southern Railroad for low volume rail operations to Durham. The lease is scheduled to expire in 1993, and the right-of-way may be abandoned and sold to private developers unless it is preserved for light rail or other transportation options.

Other alignments besides the North Carolina Railroad route could follow existing highway or freight rail right-of-way, reserved open space, or acquired private land. The amount of right-of-way that would have to be purchased would depend on the exact routes (Lauria and McLelland, 1984).

The LRT system would also require stations, maintenance facilities, and connections to existing bus systems.

Demand Requirements for Light Rail Transit

Two guides are used to establish demand requirements for light rail. The first guide is based on a typical seven percent reduction in automobile travel that is experienced when LRT is available for commuting (Vuchic, 1975). For the sample Raleigh to Research Triangle Park route, if there is a seven percent reduction in auto traffic for the year 2005 rush hour, about 900 commuters would use LRT (Exhibit 5, Report No. 1). These figures include riders from the Cary area as well as Raleigh. If the LRT system were extended throughout the region, the seven percent

traffic reduction would be equivalent to about 4600 rush hour commuters. These calculations optimistically assume that all commuters have easy access to the LRT system.

The second guide follows the technical warrant that a minimum ridership of 4000 passengers per hour is necessary to ensure viable financial operation of LRT (Vuchic, 1975). It is seen that the optimistic results of the above calculations do not meet the 4000-passenger requirement for the Raleigh to Research Triangle Park corridor and marginally exceed it for region-wide travel.

Ease of Implementation

The implementation of a light rail system in the area would be complicated by high construction cost, acquisition of right-of-way, and provision of adequate collection and distribution feeder services. Public funding for LRT projects is scarce. Whereas the USDOT has paid a significant portion of the capital costs of past LRT projects, new projects are limited by a lack of new federal funding. To create new funding sources, innovative approaches which combine private capital and public participation would have to be considered (Mass Transit, 1985). Right-of-way acquisition becomes especially difficult as an area grows and develops. If LRT is to play a role in this region's transportation needs, the existing North Carolina Railroad right-of-way should be preserved.

Impact on Congestion and the Need for New Highway Construction

The introduction of LRT could have a major impact on highway congestion if the LRT is used to its capacity. For example, the hypothetical line from Raleigh to Research Triangle Park could easily handle the over-capacity commuters from I-40 in the year 2005. I-40 could remain a two-lane highway operating at the current level of service D if the 3850 excess commuters had access to the LRT service (Exhibit 6, Report No. 1, 1.1 vehicle occupancy assumed). This ridership represents a 50 percent modal split based on I-40 traffic to RTP during the morning rush hour.

Costs

Costs are based on the example route with a service frequency required to keep I-40 operating at level of service D. Thus, 3850 passengers would be carried on the 17-mile route. This represents 25 car loads or 13 two-car trains assuming that the trains would take about 30 minutes for a round trip.

Assuming that existing right-of-way is used and that there are few if any land costs, the capital costs include those for cars, track, and stations. The example LRT system is similar to the San Diego system for which the cars cost about $700,000 each and the infrastructure including stations and track about $7 million per two-track mile (CUTS, 1985; converted to 1986 dollars).

Thus, the Raleigh to Researh Triangle Park LRT system would cost about $119 million for infrastructure and about $18 million for cars. Total cost exclusive of land equals $137 million for the 17-mile Raleigh-to-RTP alignment. Based on track length, similar costs would be expected for an RTP-Durham-Chapel Hill link.

Operating costs for the San Diego system are the lowest in the US at about $56 per total vehicle hour (CUTS, 1985). The US average is about $94. Optimistically basing the calculation on San Diego figures and assuming 10-hour service per day, five days per week, the annual operating cost is at least $2.2 million for the 13 trains and related equipment.

Summary

LRT has the potential for the highest capacity service of all the feasible options. If it is fully used by commuters, it could significantly reduce highway construction needs. However, current and expected future land use densities in the RTP area are not great enough to support LRT. If LRT is ever justified, it would be financially advantageous to use existing rail right-of-way. Therefore, the NC Railroad right-of-way should continue in state ownership.

# 7. INTERNAL CIRCULATION ALTERNATIVES FOR THE RESEARCH TRIANGLE PARK

There are several options available for providing transit within the boundaries of the Research Triangle Park. They range from low budget, demand-responsive van service to an elaborate elevated monorail. Each system has advantages. The Park circulation systems discussed in this section of the report are: 1) a demand-responsive service; 2) a fixed-route bus service; and 3) three distinct elevated monorail system designs. The demand-responsive and fixed route bus services are low-to-moderate capacity and can complement regional vanpooling, express bus, or low capacity LRT service. The monorail concepts also have high capacity configurations suitable for use with a high capacity LRT system.

## DEMAND-RESPONSIVE OPTIONS

### General Description

A demand-responsive service is a type of bus, van, or taxi service characterized by passengers boarding and alighting at any location within the service area rather than only along a designated route. Vehicles pick up passengers at times requested by the passengers as in conventional taxi service or "dial-a-ride" service. A fleet of radio-equipped vehicles is controlled by a central dispatcher who informs the driver where to pick up each rider. Such systems are the most flexible and least costly of the possible RTP circulation alternatives.

### An Example of a Demand Responsive Service

The primary purpose of a demand-responsive service would be to move people within the Park and to locations nearby like the airport. Due to inherent capacity and response characteristics of the demand-responsive system, it would not serve as a transfer link from line-haul services to final destinations during peak traffic periods. A demand-responsive service in the Park could use the existing and planned road network; no special consideration is warranted for acquiring right-of-way or for constructing a guideway system. At some point in or around the Park, it would be necessary to establish an operations center. A lot large enough to store the fleet and a building or office large enough to house a small administrative staff would be required. Depending on how the system is managed, a maintenance facility and staff may also be required. Such facility requirements are avoided or reduced if the service is operated under contract by an existing private operator.

Vehicles used for demand-responsive service may be vans which normally accommodate up to 14 passengers, mini-vans with a capacity of seven passengers, and automobiles. System capacity would depend on the structure of the service itself. If the

service were to operate during off-peak hours only, then the system size would be smaller than if it operated as the feeder service for commuters because the demand would be less. Relatively few off-peak hour trips are made in low density research and office parks.

Currently a privately owned taxicab service operates in the Research Triangle Park, and several companies serve the Raleigh-Durham Airport. Demand placed on these operators by a Park circulation system for commuters and perhaps a parcel delivery service would require them to expand their fleet sizes.

Potential Demand

Demand for a circulation system within the Park will depend on the type of transportation mode that is used to bring commuters to the Park. If the private automobile continues to serve in its current capacity with low occupancy rates, then demand for an internal circulation system will be relatively low. On the other hand, if light rail, express bus, or other line-haul service is used to transport people from outlying areas into the Park, the demand for internal circulation during the off-peak hours will be higher.

Ease of Implementation

A demand-responsive service works best when demand for conventional bus service is low and other alternatives are not available. The service would be best suited for the times of day other than peak traffic hours. A demand-responsive service is not well suited for a distribution system to complement a line-haul express bus system. The system can, however, be implemented quickly and inexpensively when compared to other public transit alternatives. There is no fixed guideway cost for the services, and vehicle costs are much lower than buses or rail vehicles. Demand-responsive systems based on automated peoplemovers would be much more difficult and expensive to implement.

Other Impacts

Impacts of a demand responsive service in RTP could be far reaching. By using a non-fixed route service, vehicles are able to move in and out of the area freely. This means that vehicles could be available to travel to the airport, or any of the surrounding cities when needed. By using a route-deviation service, the Park could give the passengers the dependability of a fixed-route service with the convenience of door-to-door delivery. Implementation of a demand-responsive service would probably have little impact on traffic congestion in the Park, unless large slow moving vehicles are used for a route-deviation system.

## Costs

Costs are based on the number and types of vehicles required to meet demand. Some high capacity demand-responsive systems use minibuses on route deviation schedules. Capital for such a system averages about $20,000 per vehicle. Operating costs depend on how the system is structured and operated.

# FIXED-ROUTE BUS SERVICE

## General Description

Fixed-route buses provide repetitively scheduled service along specific routes. Transit vehicles stop to pick up and discharge passengers at the same locations each time they traverse the route. Such systems currently operate in Raleigh, Durham, and Chapel Hill.

## Example Fixed-Route Bus Service

An intra-Park system with three routes could serve all major employment and commercial centers (Exhibit 5). The routes have lengths from 7.4 to 8.3 miles and headways from 8 to 26 minutes. The buses would use the existing road network, thus the only additional right-of-way requirement would be for bus stops and a central operations/maintenance facility. Like the demand-responsive system, it may be feasible for a private operator to provide the service from a point outside the Park, thus eliminating the need to build operations and maintenance facilities.

Bus speeds along the routes depend on traffic congestion and frequency of stops, but an average speed of 15 to 25 miles per hour could be expected. Given the three routes each of which require one 53-passenger bus operating at an average speed of 20 miles per hour, system capacity would be 3180 seat miles per hour during off-peak period. This capacity could double during peak hour service by adding an additional bus to each route thus reducing headways by one-half. Should additional demand warrant additional service, capacity could be increased accordingly.

This fixed-route system will be especially needed for those line-haul regional transportation services, such as express bus and light rail, which bring riders to central transfer points.

## Potential Demand

As with all intra-Park public transportation alternatives, demand will depend on the type of public transit system that eventually connects the Park to surrounding communities. If a rail system is used that unloads passengers at a central location, a fixed-route bus system will be in great demand during the morning and afternoon rush hours. Based on previous express bus and LRT estimates, the demand may range from 1000 to 2000 com-

muters per hour. During the off-peak hours less demand develops, and another alternative such as a demand-responsive service could be used. The off-peak demand is not estimated.

Ease of Implementation

Since major right-of-way procurements are not necessary for a fixed-route bus system, implementing such a system would not be difficult. From the standpoint of funding, private-nonprofit and public transit properties are eligible for federal and state assistance. As for demand-responsive service, fixed-route service could be tested for success before major investments are made by leasing the service from one of the existing public or private systems in the region.

Other Impacts

The existence of a fixed-route bus service in the Research Triangle Park could have a positive or negative impact on traffic congestion. If the service is used in conjunction with a regional transportation system and if the number of private vehicles in the Park is reduced, the effect will be positive. On the other hand, if no regional system is implemented and traffic volume continues to grow in the Park as expected, the buses would create additional congestion problems because they are large, slow-moving, and make frequent stops on already overcrowded roadways. Special bus ways and turnouts could reduce such congestion, however. In any event, without a regional public transportation service fixed-route bus service in the Research Triangle Park is not justified.

Costs

Costs are based on the number of buses required to meet peak- hour demand in the Park. For the example system a central operations facility and seven buses would be required (one additional bus is necessary for downtime). Costs are projected for 5.5 hours of off-peak service and five hours of peak-hour service each working day. Total operating costs are projected at $338,000 annually. Capital expenditures are projected at $2.1 million for the first year and include the price of seven buses at $160,000 each and $1,000,000 for right-of-way and facilities. Total implementation costs are about $2.5 million for the first year. The operating cost for such a system could be greatly reduced if the facilities and management of one of the local transit authorities could be used rather than creating a completely new service.

## MONORAIL

Typical monorail systems are electric powered, elevated trains running on a single beam track at heights. The most notable system in operation today is located at Walt Disney World in Orlando Florida. The silent-running, all-electric trains of

the Disney system operate at one-tenth of the energy required for commuting automobiles (Disney, 1986).

Example Monorail Systems

Three different designs are presented for possible monorail systems in the Park. The first and most extensive design (Exhibit 6) is a "figure-eight" configuration that uses mostly existing highway right-of-way and serves both the northern portion of the Park and the soon-to-be developed southern portion of the Park. The second design (Exhibit 7) serves only the currently developed northern portion and is much more efficient in terms of guideway miles than the first alternative. The third design (Exhibit 8) is a radial pattern that requires the least guideway miles and is easily expanded. The second and third designs assume that right-of-way will be donated by individual property owners in the Park.

Rights-of-way will vary depending on the design of the system. For the first alternative, only land for the stations must be acquired. This design utilizes existing highway right-of-way in and around the Park. The second and third alternatives would require substantial right-of-way acquisition. The routes are designed assuming that property owners in the Park would welcome a "high-tech" transportation system and would permit the elevated guideway to cross property boundaries in order to provide efficient transportation to their employees.

Rights-of-way for stations constitute large property acquisition. Each station requires approximately five acres plus service roadways. The second and third designs would discharge passengers adjacent to or inside the employment centers thereby reducing walk time and adding greatly to the incentives for using the system.

The speed of a monorail system may reach 85 mph; however, average speed of a system is directly related to the number of stations it serves and the station dwell time. If dwell time is approximately one minute at each station, the average speed for a monorail system serving the Park is will be about 25 miles per hour.

Capacity of a monorail system utilizing two six-car trains operating at an average speed of 25 mph is 12,200 seated passengers per hour. Both the first and second design alternatives operate two trains while the third design (radial pattern) requires three trains. Capacity and the associated capital and operating costs could be reduced by simply reducing the cars per train. Capacity for the radial pattern using three five-car trains is 15,000 seated passengers per hour.

Potential Demand

Just as the demand for other internal circulation alternatives are determined by future transit services that may serve the Park, demand for an elevated fixed-guideway system will depend on how many people are deposited at a central location and need additional transportation. A monorail would best be suited to complement a light rail or express bus system that operates from high density areas and carries large numbers of passengers to the Park. Such a situation may generate 1000 to 2000 peak hour riders based on previous calculations, and would be insufficient to justify a monorail system. A monorail operating in conjunction with a regional vanpool system would not succeed because of lower ridership and direct delivery of commuters to job locations.

Ease of Implementation

Implementation of any of the monorail designs would be the most difficult of the intra-Park circulation options discussed. Capital outlays and operating expenses are large, and time of implementation is relatively long. Private participation would certainly be necessary as well as public funding. Just as the other options would work best in conjunction with another mode of transit, so will a monorail system. Only a high capacity line haul system would justify its use, and additional distribution services using demand-responsive vans and automated peoplemovers may be necessary to completely cover the businesses in the Park.

Other Impacts

An elevated monorail transportation system would blend well with the image of a research park. While capital and operating expenditures would be high, operating efficiency measures in terms of energy use would be the best of those options discussed for intra-Park circulation if adequate demand exists. Mile-for-mile a monorail system costs about three times that for a highway; however, a monorail may carry 10 times the number of persons. The degree of effectiveness would depend on how the system is designed and the cooperation of the industries in RTP. Degradation to the topography in the Park would be minimal, and expansion of the system is possible. Unlike a demand-responsive or fixed-route bus service, a fixed guideway is required. Thus, a considerable time period for construction is required before operation could begin.

Costs

Cost for the three alternative designs differ substantially. Costs for each alternative are calculated assuming that the system operates from 7:00 am to 6:30 pm each working day with five hours of peak service. The first alternative operates two trains during off-peak periods and requires additional trains during peak service. The second alternative operates one train

during off-peak times (unless demand requires more seating capacity) and two trains during peak service. The first and second alternatives assume no right-of-way expenditures and that tenants desiring "front door" service will pay for the cost of their station. The figures used in projecting cost are provided by Walt Disney Productions and are based on 1983 dollars. A conversion factor of about 1.08 based on the Consumer Price Index could be used to convert the costs to equivalent 1986 costs.

Capital Costs:

| | |
|---|---|
| $10,000,000 | per mile of guideway |
| 2,000,000 | per radial hub station |
| 1,000,000 | per station |
| 500,000 | per 6-car train |
| 420,000 | per 5-car train |

Operating Costs:

| | |
|---|---|
| $ .08 | / seat mile |
| 7.09 | / train mile |
| 177.25 | / train hour |

Monorail Design #1:

This design (Exhibit 6) uses eleven miles of guideway and thirteen stations. A total of four full length trains are required. Capital expenditures required to construct the system are estimated to be $125 million. Operating expenditures are estimated at $5,849 per day or approximately $1.5 million per year assuming 250 operating days.

Monorail Design #2:

The second alternative (Exhibit 7) is simply a loop that serves currently developed portions of the Park. The design requires eight miles of elevated guideway and one main station. Other stations would be provided by property owners in the park where employee densities are high enough to warrant location of the system on or near their facilities. Small clusters of employment centers may also create demand high enough to warrant a station. In this case, some companies may find it feasible to construct some type of peoplemover to link their facility with the monorail station.

The total cost of guideway, station, and trains for this alternative would be approximately $82 million assuming property owners provide their own stations. Station costs are not included because they can range from just a platform to an elaborate building. Operating costs are calculated for 16.5 hours of service each working day and 250 working days per year. Annual operating expenditures are projected at $750,000 or about $3,000 per day. Total start-up cost for the system for the first year is estimated at $83 million.

Monorail Design #3:

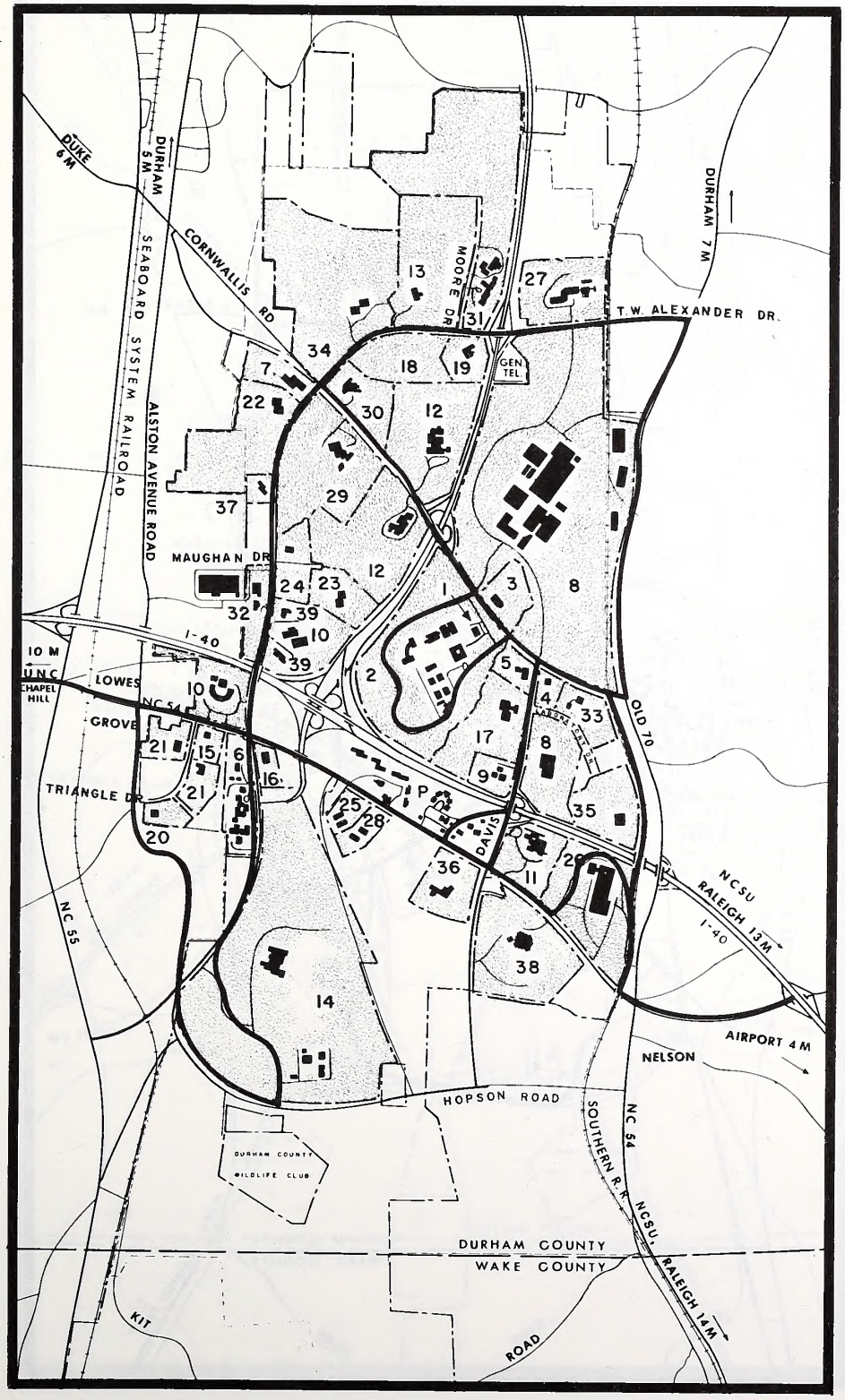
The third design (Exhibit 8) takes the form of a radial pattern and is the most efficient alternative in terms of guideway requiring only 6.5 miles. This alternative makes the same assumptions as alternative number two regarding stations and right-of-way. The system would require operating two five-car trains during off-peak service and three five-car trains during peak hour service. The pattern serves the currently developed portions of the Park but can be easily expanded for future development.

Total cost of guideway, hub station, and trains for this alternative would be approximately $68 million. Calculations for operating cost are based on six-car trains, thus these values are inflated to some degree. Operating cost are projected conservatively at $5,000 per day or $1.25 million annually. Total start-up cost for the first year is estimated at $70 million.

Summary

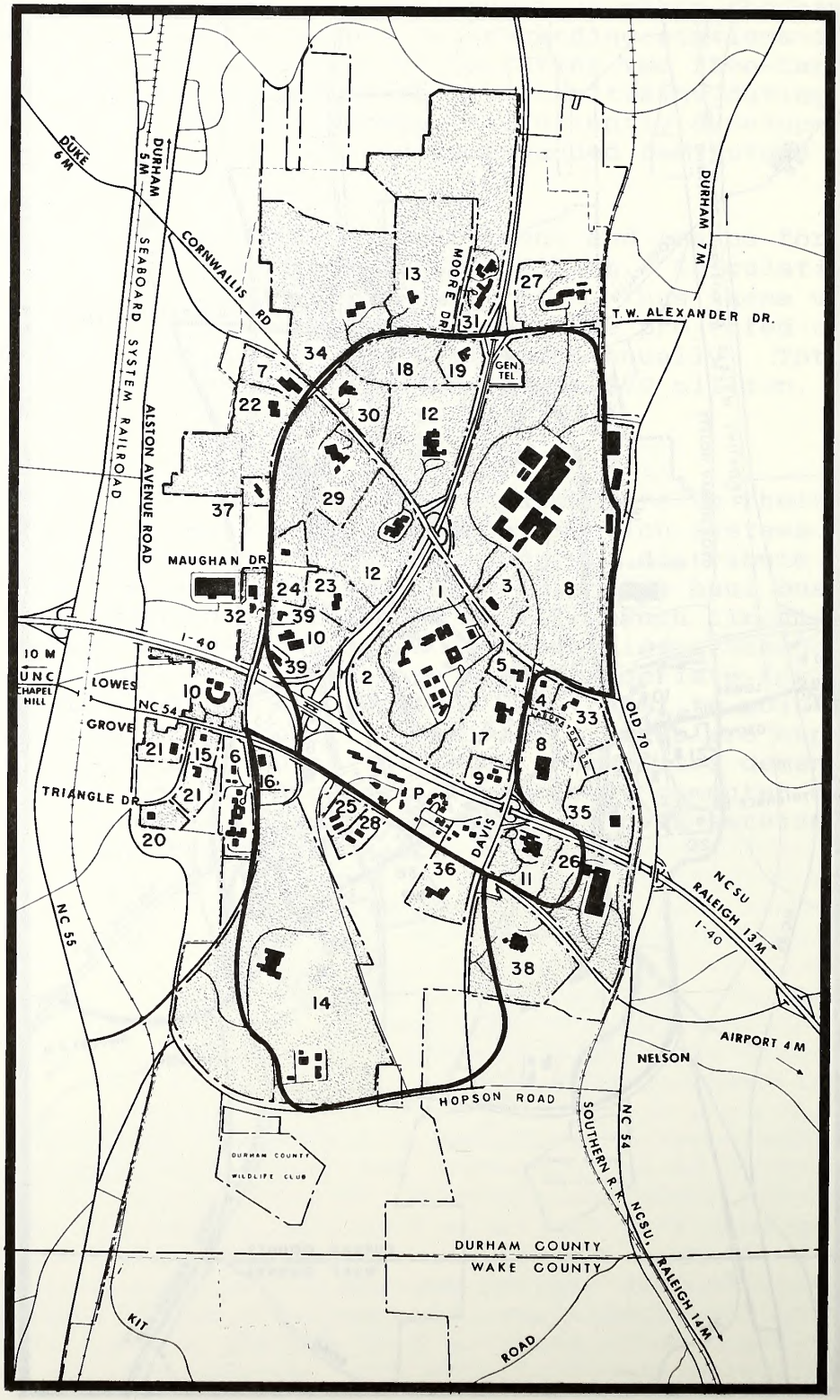
Ridesharing options that deliver commuters to their place of employment do not require separate distribution systems. A circulation system will only be necessary to distribute commuters throughout the Research Triangle Park if a line haul bus or rail system is implemented for regional travel. Such circulation systems include fixed-route buses and monorails. Demand-responsive, taxi-like services are more appropriate for non-rush hour circulation within the Park and for travel to points outside of the Park like the Airport. Monorail systems are expensive and are unjustified based on the level of expected demand. Fixed-route bus service appears affordable if commuter demand is sufficient. Buses may also be used for off-peak service to points within and beyond the Park.

Exhibit 5



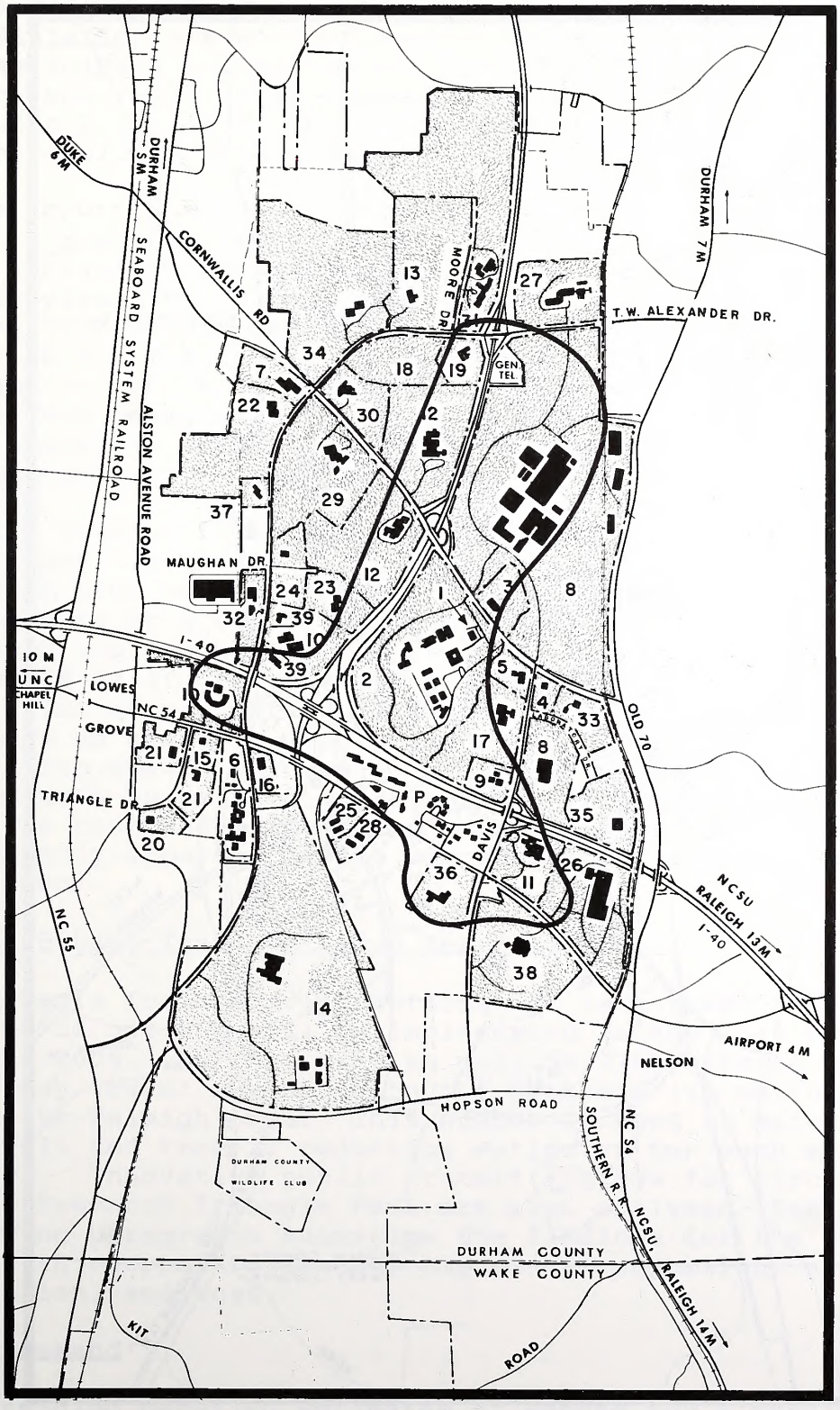

**FIXED-ROUTE BUS**

Exhibit 6



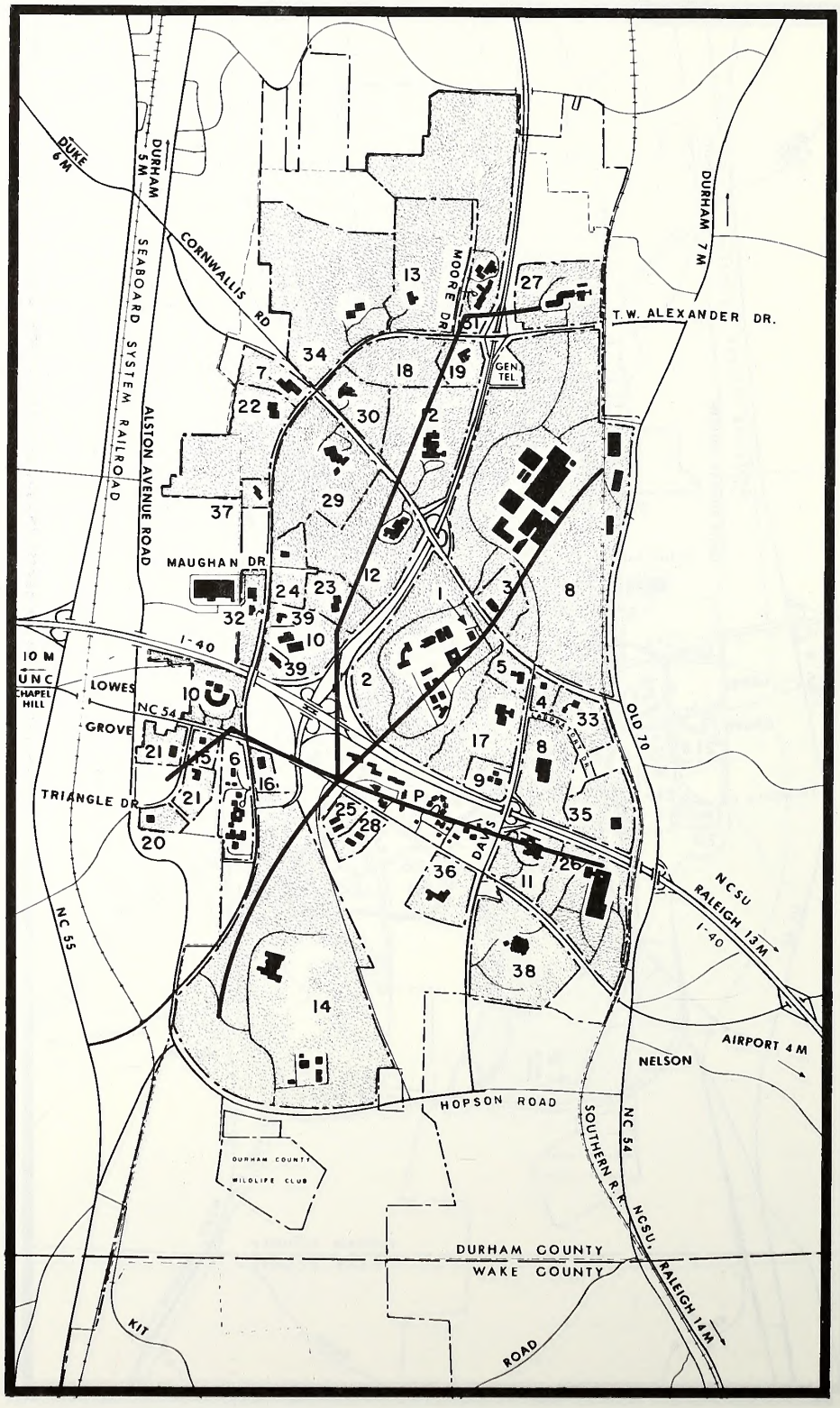

**MONORAIL No. 1**

Exhibit 7




**MONORAIL No. 2**

Exhibit 8




**MONORAIL No. 3**

## 8. SUMMARY COMPARISONS AND RECOMMENDATIONS

### Public Transportation Opportunities

This report and its companion reports No. 1: Trends and No. 3: Implementation are written with a certain amount of urgency. We must anticipate the future and plan for it now, not wait for the future and react to it. Now is the time to begin the planning for a regional public transportation system for the future metropolitan Triangle.

This report examines the ability of public transportation services to meet the travel needs of the region. Ridesharing options, including carpooling, vanpooling and express bus, perhaps complemented by a system of commuter lanes, offer the most attractive, least costly services. A light rail system may hold promise for the future if rapid growth continues and high demand density can be concentrated along corridors. Monorail, metrorail, and commuter rail are not suited for intercity commuter travel in the Triangle region because of insufficient demand and cost.

Public transportation can make significant contributions to commuter travel in the Triangle region. Currently during the morning rush hour one car in ten has two or more people in it. This translates to a relatively low 18 percent use of ridesharing by commuters and a nine percent traffic reduction from what traffic would be if everyone drove alone. Successful implementation of a program utilizing vanpools and express buses, complemented by commuter lanes, can raise the rate of public transportation use to a level as high as 33 percent and reduce traffic volumes by as much as 30 percent (Exhibit 9). However, the relative cost and travel time advantages of public transit must be clearly apparent to the commuter for the higher mode split to occur.

### Example of Public Transportation Services

As a basis for comparing options, it is assumed that some combination of options will be implemented in the I-40 corridor by the year 2005. By that time as many as 7700 morning rush hour commuters may travel westbound to the Park and its surrounding area from the Raleigh area. This number is used to determine the demand levels and traffic reduction estimates for each mode (Exhibit 9). Innovative public transit systems for circulation within the Research Triangle Park are also analyzed (Exhibit 10). The following paragraphs summarize the findings for the sample services with respect to demand, impact on congestion, ease of implementation, and cost.

### Potential Demand

Determining detailed estimates of demand for a public transportation alternative is a time consuming, complicated process

that is beyond the scope of this study. In order to estimate approximate levels of demand, a "what if" analysis based on typical ranges of demand is used. To test and compare each option, only the I-40 corridor demand between Raleigh and the Research Triangle Park is considered. By the year 2005 as many as 2500 commuters along this corridor will use public transportation if it provides convenient, fast service that is comparable to that of private automobiles (Exhibit 9). However, by the year 2005 there will be as many as 3630 commuters in excess of I-40 capacity trying to use the facility.

The Impact on Congestion

To provide a balanced transportation system to meet all of our future travel needs, complementary and coordinated regional transit and highway projects are needed. The recommended carpooling, vanpooling, express bus, and commuter lane options cannot by themselves reduce future highway congestion to acceptable levels (level of service D). Indeed, planned highway improvements cannot either. For the low density Triangle region it is expected that even though public transportation can significantly increase the people carrying capacity of existing highways, additional highways will be needed if traffic congestion is to be acceptably low.

Consider Exhibit 1 which summarizes comparative factors for public transportation and new highway construction. The information shown is based on traffic demand projections for the section of I-40 between Raleigh and the Research Triangle Park. In 1986 approximately 4000 westbound vehicles use I-40 in the morning rush hour (Exhibit 6, Report No. 1 of this series). This number is approximately 300 vehicles per hour (330 commuters per hour assuming a vehicle occupancy rate of 1.1) in excess of an acceptable level of service D volume for the present two lanes.

In the year 2005 the I-40 westbound rush hour traffic may grow to 7000 vehicles per rush hour - about 3300 vehicles (3600 commuters) in excess of acceptable volumes for two lanes. Thus, an additional lane is more than justified on I-40. Since one lane can carry at most only 2000 vehicles an hour, even at near traffic jam conditions (level of service E), a new road in a parallel corridor also appears warranted even with three lanes on westbound I-40. Similar analyses can be made for other corridors in the region as described in Report No. 1.

Ease of Implementation

The relative ease of implementing different public transportation options is determined by the amount of right-of-way that must be acquired, the amount of construction, the availability of existing facilities, cost, availability of funding, and the degree of inter-jurisdictional cooperation involved. Right-of-way requirements present little problem except at interchanges where bridge supports and special lanes use available medians.

Exhibit 9

Comparative Factors for Transportation Options
in the Raleigh to RTP I-40 Corridor

| | New Hwy. Lane in Each Dir. | Carpools | Vanpools | Express Bus | Commuter Lane | LRT |
|---|---|---|---|---|---|---|
| 1986 Commuters (people/hr.) | 330 | 800-1200 | 250 | 0 | 0 | 0 |
| 2005 Commuters (people/hr.) | 3600 | 1400-1900 | 500-2500 | 100-2000 | 2000-2500 | 900 |
| Maximum Commuters (people/hr.) | 2000 | -- | -- | 10,000-20,000 | 10,000-30,000 | 6,000-40,000 |
| Traffic Reduction | 0% | 9-17% | 5-30% | 1-25% | 15-32% | 7% |
| Mode Split | 18% | 18-25% | 6-33% | 1-26% | 25-33% | 8% |
| ROW Requirements | Exists | None | None | Commuter Lane for High Volumes | Exists | Exists |
| Facilities | None | None | P&R lots, Administration | P&R lots, Storage | P&R lots, Interchange | Stations, Storage, Maint.,etc. |
| Implementation | Bridges | Easy | Moderate-Easy | Moderate-Easy | Moderate-Difficult | Difficult |
| 1986 Capital Costs | $10M | 0 | $76K-$4.3M | $320K-$1.6M | $30M | $137M |
| 1986 Operating Cost | $114K | $150K | $182K-$1.0M | $56K-$281K | $114K | $2.2M |

Exhibit 10

Comparative Factors for RTP Circulation Options

| Factor | Demand Response Vans & Taxis | Fixed Route Buses | Monorail #1 | Monorail #2 | Monorail #3 |
|---|---|---|---|---|---|
| 1986 Commuters | Not Avail. | 0 | 0 | 0 | 0 |
| 2005 Commuters | -- | 1000-2000 | 1000-2000 | 1000-2000 | 1000-2000 |
| Maximum Commuters | -- | 3200 | 12,000 | 12,000 | 15,000 |
| Mode Split | -- | 10-26% | 10-26% | 10-26% | 10-26% |
| Traffic Reduction | -- | 10-25% | 10-25% | 10-25% | 10-25% |
| ROW Reqmts. | Exists | Exists | Exists | Donated | Donated |
| Facilities | -- | Bus Shelters | Stations, Storage, Maint. | Stations, Storage, Maint. | Stations, Storage, Maint. |
| Implementation | Easy | Easy | Difficult | Difficult | Difficult |
| Capital Costs | -- | $2.1M | $125M | $82M | $68M |
| Annual Oper. Costs | -- | $338K | $1.5M | $750K | $1.25M |

Carpools, vanpools, and express buses require no right-of-way because they use existing highway lanes. Commuter lanes and light rail transit can be built on existing highway or rail rights-of-way. Construction requirements become more complicated with dedicated facilities like commuter lanes and light rail. Commuter lanes require not only new road surface, but also special treatments where access and egress occur. While relatively difficult to build, they also present flexible options for service in that they can carry carpools, vanpools, and express buses. If necessary they can also be converted to general traffic lanes. Light rail facilities require more construction since stations are necessary. They also present an inflexible service option; they are dedicated to light rail service.

Cost

Costs include both capital costs and operating costs. Capital costs cover right-of-way, equipment, stations, and park-and-ride lots. For the options being considered, the capital costs range from a low of zero for carpools to a high of $137 million for light rail between Raleigh and the Research Triangle Park. Traditionally a significant fraction of capital costs are subsidized by federal and state sources. The construction of commuter or general highway lanes would be funded at least partially through gas tax dollars. Equipment and construction costs for light rail, express buses, and vanpools could be subsidized in a variety of ways.

Operating costs pay for salaries, energy requirements, and maintenance. They range from relatively small amounts for carpool matching programs to $2.2 million annually for light rail. Virtually all of the operating costs for ridesharing by carpools, vanpools, and express buses are paid for "out-of-pocket" by users. Such costs or fares are often viewed as more expensive than a private automobile. Operating costs for light rail systems are eligible to be federally subsidized, but such subsidies are being reduced.

Recommendations

The primary recommendation of this study is for city, county, and state officials to maintain and enhance regional interest and participation in public transportation planning and eventually operation. Too much reliance on highways and the private automobile can only lead to increased congestion as the Triangle matures into a metropolitan area.

Given the need to continue the consideration of public transportation options, the following recommendations are presented for leaders in the Triangle Region.

1. For the short term (two to five years) develop an implementation plan that focuses on ridesharing options

complemented by commuter lanes. Carpools offer the least expensive, perhaps highest ridership option. Express buses are attractive in that they can serve the commuter during rush hours and the non-commuter during the middle of the day. Vanpools are restricted to commuters and may be only moderately successful as long as there are apparent cost and time penalties versus the private auto. Vanpool subsidies could help alleviate the cost problem, and a commuter lane could help the time problem.

2. Keep the light rail transit option open for the future by preserving NC Railroad right-of-way. If land use becomes concentrated along rail corridors, LRT can be an extremely efficient, high capacity alternative to highway travel.

3. Identify other corridors in which land use may become concentrated in the future and thereby require light rail and other public transportation services.

4. Charge a yet-to-be-formed regional public transportation planning organization to develop a comprehensive action plan for carrying out the recommendations of this report. In the plan include provisions for the following:

a. A coordinated regional land use and transportation study to identify corridors where higher densities are desirable and where public transportation can be concentrated.

b. A detailed demand, marketing, revenue, and funding study for the options beginning with express bus, which is the most likely public transportation alternative that can be provided by a private company. Also work with Tri-A-Ride and area employers to increase the use of carpooling and vanpooling by identifying new markets and appropriate incentives. Coordinate such ridesharing efforts with staggered work hour strategies.

c. Entrepreneurial opportunities in public transportation. Traditional government-sponsored subsidies are decreasing, and private funding innovations are needed.

d. Transportation systems simulations to test alternative operating and pricing strategies and determine their effects on demand, mode split, and congestion.

5. Continue to evolve land use policy and density guidelines to meet the goals for future growth. Identify corridors for clustered, high density development in order to preserve open spaces and reduce urban sprawl. And examine the implications of such high density development on public transportation service.

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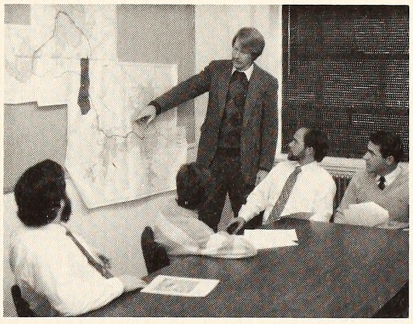
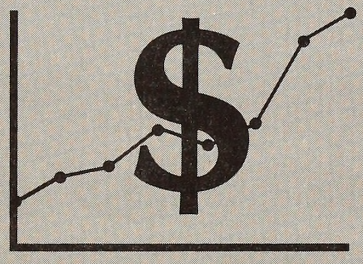
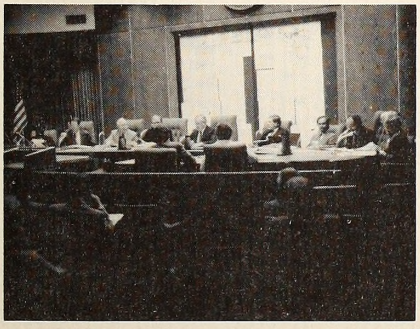
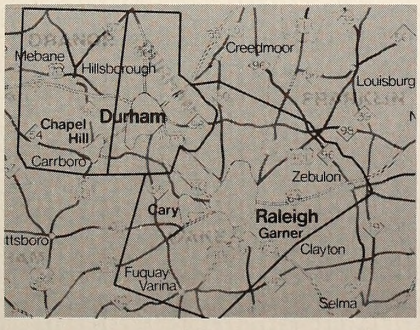
# Travel in the Triangle










## IMPLEMENTATION

# TRAVEL IN THE TRIANGLE: IMPLEMENTATION

Report No. 3

Research Triangle Area Public Transportation Study

March 1987

Department of City and Regional Planning
University of North Carolina
Chapel Hill, NC 27514

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## PREFACE

This report is the third of a series of three resulting from the Triangle Area Public Transportation Study. Report No. 1, "Travel in the Triangle: Trends" identifies potential problems. Report No. 2, "Travel in the Triangle: Choices" presents an analysis of transportation service options for the region. This report, "Travel in the Triangle: Implementation," presents proposals for implementing the options selected for new public transportation services in the Triangle.

The Triangle Area Public Transportation Study, funded by the North Carolina Department of Transportation (NCDOT) and the Urban Mass Transportation Administration (UMTA), is conducted jointly by researchers from the University of North Carolina (UNC), North Carolina State University (NCSU), and Duke University (Duke).

This report and an earlier discussion paper benefitted from comments, suggestions, and questions raised by members of the Transportation Advisory Committee of the Greater Raleigh Area and of the Durham-Chapel Hill-Carrboro Area. Associates of UNC's Institute of Government provided valuable information on legal and administrative issues. As in the case of the first two reports, the Transportation Study Steering Committee assembled to review the research, and this proved extremely helpful.

## TRAVEL IN THE TRIANGLE: IMPLEMENTATION
## EXECUTIVE SUMMARY

The leaders of the Triangle area have an opportunity to address region-wide transportation issues before they become serious problems. Report No. 1 analyzes the travel, population and employment trends and indicates that before the year 2010 nearly all major highway corridors will be at or above capacity even with the construction of planned highway improvements. Report No. 2 examines the alternatives and concludes that several public transportation options, such as ridesharing, express bus, commuter lanes, and possibly light rail, can reduce projected levels of congestion in the Triangle area. This report reviews the organizational options and proposes the establishment of a Regional Public Transportation Authority (RPTA) to plan, finance and operate public transportation services in the Triangle Area.

The RPTA should be responsible for coordinating public transportation services within the region and for providing services outside and between existing urban service districts. The RPTA should have staff that is able to analyze travel demand, market needed public transportation, work with state and local highway planners and local transit operators to identify cost-effective solutions, and operate transit services to meet regional transportation needs.

The RPTA should be empowered to collect fees, impose special assessments, issue revenue bonds, receive grants and other funds and own real property. Although not a unit of general government, the authority should enjoy a permanent existence, substantial independence, and unified management with a clear mission. The RPTA should be accountable to the public through its commissioners who may be appointed for fixed terms by the elected officials of Durham, Orange and Wake counties and the municipalities of these counties.

The RPTA should develop a special set of relationships to the Research Triangle Foundation, the Raleigh-Durham Airport Authority and the Triangle J Council of Governments. Through these relationships, the RPTA should seek to coordinate transportation services with employment growth taking place at RTP, RDU and other growth centers. It should also seek participation in land use planning and zoning decisions which will shape the pattern of physical development in the region.

The recommendation of creating an authority to implement needed public transportation actions is based on two considerations. First, the prospect of growing traffic congestion in the Triangle Region poses a serious problem. Increasing travel times, delays in commuting to and from work and possibly more expensive trips for area residents constitute only part of the problem. In addition, the attractiveness of the region to potential employers and residents will decline unless traffic congestion is kept within reasonable bounds. Smaller metropolitan areas, such as those in the Triangle Region, with

high quality of life and low costs of living have an advantage relative to larger metropolitan areas with more urban amenities but with more serious urban problems. Ease of access is an important aspect of the Triangle Area's attractiveness. To maintain this level of access as the region grows will be a challenging task.

Second, the results of the analyses in Reports No. 1 and No. 2 are not encouraging. The study of trends projects increasing congestion even with the construction of planned highway improvements. The study of choices indicates that serious congestion may remain even after additional highways are built and regional public transportation services are substantially increased. To alter these undesirable outcomes will require leaders with the courage to make difficult decisions that will influence the demand for travel as well as the supply of facilities and services. An administrative mechanism with sufficient standing to carry out the mandate of area leaders would also be required. Less ambitious organizational alternatives are likely to be inadequate.

The RPTA should not be established immediately. It should grow out of the process that this study has initiated. The presentation of Reports No. 2 and No. 3 to the joint meeting of the Greater Raleigh TAC and Durham-Chapel Hill-Carrboro TAC ends this study. That meeting should also mark the beginning of a process continuing the work on regional transportation problems.

Local public officials are in the position to determine the agenda for future work. The North Carolina Department of Transportation is ready to respond to local initiatives. The action agenda suggested below is intended to identify some major issues that local leaders should consider.

UPDATE TRENDS

Timely information on the rate and distribution of area growth is essential to sound planning and assessment of potential problems.

DETERMINE THE FEASIBILITY OF PUBLIC TRANSPORTATION OPTIONS

The analysis of choices in Report No. 2 represents a first-cut examination of the feasibility of various public transportation options. As noted in Report No. 2, promising options deserve more careful scrutiny before substantial investments are made in marketing and offering new services.

ANALYZE MAJOR TRANSPORTATION CORRIDORS AND IDENTIFY NEW CORRIDORS OR EXPANSIONS OF EXISTING CORRIDORS TO ACCOMODATE GROWTH

Additional highway lanes and several public transportation options require right-of-ways for future use. Judicious purchases of key parcels can lead to the preservation of corridors and the space to accommodate increasing public transportation services as the demand for service grows in the future.

REVIEW THE ELEMENTS OF THE NEW ORGANIZATION

As with Report No. 2, the assessment of organizational issues in this report is limited in scope. The RPTA needs to be designed more precisely. It should then ultimately be created by legislative action. The services to be provided, legal powers, governance, and administrative structure must be designed in detail.

SECURE FUNDING TO CONTINUE THE STUDY PROCESS

The willingness of Triangle Area jurisdictions to provide funding is an indication of the relative importance of the problems and opportunities flagged in this study. Local leaders should establish a fair funding formula and solicit contributions from all jurisdictions. The North Carolina Department of Transportation and private entities may be willing to provide additional financial assistance after local commitments have been secured.

HIRE STAFF ASSISTANCE TO CONDUCT THE NECESSARY ANALYSIS

Professional help is needed if the study is to continue. Members of the Transportation Study Steering Committee have been generous in contributing their time but are the first to suggest the eventual provision of permanent staff. The steering committee should continue to meet until permanent staff is available.

REVIEW ALTERNATIVE FUNDING MECHANISMS FOR THE NEW ORGANIZATION

Several funding alternatives are identified and described in this report. The Institute of Government at UNC-CH should be asked to develop enabling legislation and a financing plan for any proposed new organization. The city, town and county attorneys of the area jurisdictions should review and comment on the proposal.

The steering committee and the TACs have made substantial progress to date in discussing the important transportation issues and arriving at a shared understanding of the problems and opportunities facing the Triangle Area. At the joint TAC meeting, the steering committee should be given official standing. Its membership should include a representative of each jurisdiction on the TACs. Local jurisdictions should continue to commit staff to the planning effort. The steering committee should meet again early in 1987 to plan additional feasibility studies and ways to help educate the public. The NCDOT should continue its involvement and support.

Local officials should respond to this exemplary effort by building a constituency for regional public transportation and a concensus of public support. The public's awareness, the available technical talent and expertise, and the finanical resources of the relevant participants can combine to create the potential for success. Leadership from local jurisdictions is needed to solve the Triangle Area's transportation problems before they reach crises proportions.

## TRAVEL IN THE TRIANGLE: IMPLEMENTATION

## TRANSPORTATION: A REGIONAL PROBLEM

The Triangle area is quickly growing into an urbanized, and interdependent region. The heavy commuting that now exists throughout the region from one jurisdiction to another demands that a region-wide approach be adopted to solve congestion problems. This inter-jurisdictional travel is expected to continue to increase substantially during the coming decades. Highway improvements alone cannot adequately address the serious traffic congestion already experienced during peak hours along some of the Triangle's major corridors and anticipated for most corridors linking the Research Triangle over the next 20-25 years. Success in solving the region's transportation problems requires careful attention to two areas: the development of appropriate service solutions, which is discussed in Report No. 2, and the determination of a feasible implementation strategy which is the subject of this report.

In about 20 years, the population of the Triangle region will approach one million and employment will be near 600,000, almost twice current levels. For the three-county area as a whole, there will be more in-commuting than out-commuting and more through traffic. Demand for transportation facilities and services will be increased further by the area's unique employment centers. Area universities, area hospitals, state government, and federal/national facilities bring substantial numbers of visitors to the Triangle. As permanent and transient populations grow, tremendous pressure will be placed on the area's transportation system. Greater traffic congestion will be the result unless mitigating public actions are taken.

The spatial distribution of population and employment are as important as the overall levels. Three aspects of this pattern are particularly noteworthy. First, major employment centers - exist outside of the employment nodes in Raleigh, Durham, Chapel Hill and Cary. The Research Triangle Park and the Raleigh-Durham Airport are the most noteworthy employment growth centers. Second, residential development is low density, although most recent developments and future developments will achieve higher densities as land prices continue to escalate. Third, the combination of rapid employment growth at RTP and RDU and residential development near these employment nodes is generating a single metropolitan area. This multi-nucleated pattern of employment clusters results in complex patterns of commuting.

Regional economic growth and physical development have additional transportation implications. The transportation needs in the region are changing. As the region becomes more urbanized and as congestion and parking problems become more pressing, the need for non-highway improvements will increase. Report No. 1 shows that highway corridors in the region, even after planned improvements will be inadequate to meet the levels of expected future demand. Moreover, we cannot easily afford to build enough

highways to meet the projected demand for regional travel. The issue, therefore, is not whether to build the planned highway improvements but to determine what else is needed to address the region's transportation problems. The possibility of expanding existing corridors or establishing right-of-ways for new corridors deserves further study. Viable public transportation options are identified in the subject of Report No. 2. Recommended options include carpools, vanpools and express bus service complemented by commuter lanes in the near term, and possibly light rail transit in the future. The extent to which these services mitigate congestion and other transportation problems will depend on how effectively they are planned, marketed and operated.

## Organizational Requirements

Given the Triangle area's growth and development, any organization established to deal with the area's transportation problems should be a regional organization. This requirement is an obvious response to the demographic, economic, and spatial realities of the Triangle Area which are creating a single functional area with major growth centers (RTP and RDU) in the unincorporated middle of the region. A regional organization can address the needs of people and employers located outside of the urban service districts, and it can examine the overall need for service and facility improvements. Futhermore, a regional organization can lead efforts to coordinate public transportation services.

A review of the existing transportation planning in the region leads to the conclusion that the existing highway decision-making process proceeds with reasonable efficiency. On the other hand, the status of public transportation in the region creates the need for a regional organization. First, additional services are needed to address the problems of growing congestion. Second, greater coordination of existing transit service planning and implementation could result in more efficient, linked services throughout the region.

A regional organization should have the capability to provide public transportation services, coordinate regional public transportation services, participate in highway planning, and bring to the attention of local officials the effects of physical development decisions on regional transportation. To take this mandate seriously, the organization should be able to perform four functions:

-Planning,
-Marketing,
-Service delivery, and
-Financing.

Planning should be viewed in three ways. First, the organization should be aware of but not duplicate the transit planning performed by the three cities with transit systems.

Rather, transit planning should be focused on operations planning, which is short-range and very practical in orientation. Second, the regional transportation organization should examine current service levels relative to demand on an on-going basis and plan public transportation outside of existing urbanized areas to relieve congestion. Third, the organization should be a regular participant in the thoroughfare planning process. Planning also includes evaluation, both of policy and service impacts and of the transportation decision-making processes, and coordination among jurisdictions and transportation modes.

Marketing is an increasingly important function for transportation providers, especially in this context where the focus is on commuters and not immobile populations. Informing the public of the transportation services that are available is not sufficient for effective marketing. Rather public transportation services must be "sold" to the public. Effective marketing involves identifying the population segments which could benefit from public transportation services, designing delivery systems that meet their requirements for speed, convenience and safety, balancing the demands for economical service and service amenities, and advertising services through the media and other appropriate channels. Marketing can increase ridership and usage of public transportation services by appealing to the population's personal preferences and collective concerns. Preferences relate primarily to questions of cost and convenience; collective concerns relate to the regional benefits of less automobile traffic. A convincing marketing campaign may be the most critical element in getting started properly.

Service delivery requires effective management of service operations. A regional organization may operate public transportation services directly or contract with public or private service operators. A multi-service organization may do both. Direct service delivery requires the regular operation of vehicles and supervision of personnel. Contracts may be drawn for the complete provision of a particular service or for a specific portion of services such as vehicle maintenance. Contracting should be limited to operations since the regional organization needs to have in-house management and planning capability to remain viable. Effective management should be able to carry out studies comparing the service levels and costs for alternative modes of service delivery and to select cost-effective service delivery mechanisms.

Financing and the ability to raise revenue will be necessary to defray the costs of operations and overhead and to purchase the capital facilities and rolling stock required for service delivery. Carpools and vanpools may be operated in a decentralized manner and costs may be covered fully by car poolers or by employers operating vanpools. Or the regional transportation organization may choose to subsidize carpools or vanpools to make these alternatives more attractive to the public. Fares collected from express service may not be adequate to cover all costs and may require subsidies, notwithstanding the

fact that commuters have greater ability to pay than immobile populations.

Revenues can also be raised from debt capital, from other fees, assessments or taxes, and from voluntary contributions or grants. The appropriate combination of public and private revenue sources depends on the specific service options recommended for implementation. A dedicated funding source may be the key to solvency. Financing alternatives are discussed more fully in Appendix A.

The regional organization should be designed carefully to embody these capabilities for successful operations and management. The criteria of operational efficiency, compatibility with existing organizations, accountability and legal powers should be used in designing the organization. These design criteria are applied in this report to determine the recommended organizational form.

The regional organization requires a distinctive identity and integrity, sufficient size, and relative permanence to deliver an evolving array of services and to operate them efficiently and effectively. The staff must be able to analyze service options and costs, plan efficient service delivery and systems influence the actions of other organizations.

The regional organization must have a specific mandate to define its scope of operations and clarify its relationships to insure compatibility with other transportation entities. The organization should not duplicate planning efforts or services but should have some ability to coordinate activities and participate in related planning efforts. An organization focused on regional public transportation services should also have the standing to participate in state and local highway planning in order to create a balanced, multi-modal transportation system in the region.

The regional organization should be accountable to the public for the provision of services and for the efficient use of any resources received from public or private sources. A public entity would be responsible to the jurisdictions in the region; a public-private entity, would be accountable to private sector participants as well.

Control of the regional organization may be ultimately vested in the municipalities and counties of the Triangle area. In addition to local jurisdictions, it may be reasonable to involve the NC Department of Transportation, the Research Triangle Foundation, and the Raleigh-Durham Airport Authority. A case may be made for also including major employers that express interest in participation.

Given the large number of possible "governors" beyond the local jurisdictions, it may be reasonable to expect a threshold commitment of financial support before an entity were allowed to

participate in establishing the regional organization. Governance will reflect the structure of financial support.

Besides efficiency, compatability, and accountability, the regional transportation organization should have defined legal powers. These powers will clarify the organization's scope of activities and means of generating funds. By defining these attributes in advance, the region's leadership should be able to discuss the regional transportation organization openly and design it without raising undue fears among existing transportation entities.

## REGIONAL ORGANIZATIONAL OPTIONS

Which organizational arrangements have the most potential for becoming the dynamic, flexible and creative entity needed to meet the emerging transportation needs of Triangle Area residents? Two broad categories of organizational options should be considered:

1. Modifications to the existing transportation organizations in the region
2. New organizational structures The existing decision-making process is described in Appendix B.

Modifications could be made to change the status quo. One is to have the TCCs and TACs meet jointly. Although the TACs would still work independently in preparing and approving their respective TIPs for each MPO, joint meetings would promote coordination.

Secondly, the MPOs could merge resulting in one TAC, one TCC, and a single TIP for the region.

A third option is some type of informal cooperation among the elected officials from the major jurisdictions in the region. For example, the mayors and county commission chairpersons could decide to have a series of meetings, which presumably need not be restricted to transportation issues. The Triangle J Council of Governments provides this function currently and could take the lead role.

A fourth modification is the establishment of a regional transportation technical task force. As part of this study a technical steering committee met to review draft reports and provided invaluable feedback. These technical experts could continue to meet on a regular basis and prepare, analyze, and recommend specific regional transportation services and facilities. The results could then be submitted to the area TCCs and TACs. The steering committee would thus become a task force with members representing the elected officials of each jurisdiction.

A fifth option is to provide regional public transportation by enhancing the role of the NCDOT. The current thoroughfare planning process could be expanded to include public transportation planning, perhaps through the Public Transportation Division. The core staff, support staff, regional offices and relationships with UMTA are already in place. The NCDOT could go to the General Assembly to raise revenue and has already become a recepient of UMTA funding throughg other projects. The NCDOT could contract for services as it now does with the Cary-Garner service. It could develop new funding schemes working with local jurisdictions in the region.

On the other hand, NCDOT has little track record in public transportation operations or operational support. New funding

would be necessary to carry out this new function. More importantly, the NCDOT may not be prepared to engage in the same activities in other metropolitan areas of the state. Although it could fund demonstrations in specific areas, NCDOT would be unlikely to establish an on-going program in just one region.

Finally, the role of the Triangle J Council Of Governments (TJ COG) could be enhanced. One option is to ask TJ COGto coordinate the activities of the two MPOs. Another option is to designate TJ COG as the MPO for the three-county Triangle Region. Clearly, these changes would increase TJ COG's role in public transportation and establish a broader regional decision-making framework. However, TJ COG has not performed a major role in public transportation to date because it lacks transportation expertise.

Each of these options represents changes that are relatively easy to implement and would probably improve decision-making within the region. However, when examined against the four functions that should be performed by a regional organization, these options do not fare well. Taken as a group, they can improve planning and coordination but hold little promise for effective marketing, service delivery or revenue raising. Except for the technical steering committee and the NCDOT, there is not sufficient expertise to analyze and manage public transportation services. Committee members lack the time to do the required work.

Considering the four organizational criteria, the modifications would be compatible with existing organizations and could achieve accountability and operational efficiency with increases in staff and resources. Yet, the most attractive modification involving an expanded role for NCDOT suffers because NCDOT lacks the mandate to provide expertise to the Triangle Area while not doing the same for other areas of the state. Enhancing the role of NCDOT could also reduce the enthusiasm and involvement of local jurisdictions. Thus, none of the modifications have sufficient standing to play a central role in addressing the region's transportation problems. However, several are attractive as transitional organizational vehicles to promote regional public transportation in the near term.

<u>New organizational forms</u> constitute the second category of organizational options to be considered. These include the following:

A Regional Public Transportation Authority (RPTA)
A Regional Transportation Service District (RTSD)
A Regional Transportation Management Association (RTMA)

Precedents for a successful multi-county transit authority exist in several areas of North Carolina. These include a four county transportation authority in the northeastern part of the state and a five county authority in the north central part of the state. A regional transportation authority could be charged

with the responsibility of coordinating all public transportation services and providing services outside the service areas of individual cities. The regional transportation authority would supplement, not replace, the transportation systems in Raleigh, Durham, and Chapel Hill.

In North Carolina, numerous types of service districts with different powers have been used successfully. Water management is one example. The service district within the Research Triangle Park provides yet another precedent. Action by the North Carolina General Assembly would be required if the service district were empowered to tax and to operate services directly or under contract.

RTMAs exist in several metropolitan areas across the county, such as in Hartford, Connecticut and El Segundo, California. An RTMA is usually a private-sector organization of employers who band together to solve mutual transportation problems. RTMAs either contract for, or provide directly, a variety of ridesharing services, and frequently participate in the local transportation planning process by making proposals and commenting on highway and parking issues. They may also contract for or operate transit services. These activities enable member companies to attract high-quality employees, reduce outlays for parking facilities, and promote the environmental quality of the area in which they are located. In the Triangle Region, an RTMA could be formed by employers in the Research Triangle Park and its periphery, or the TMA could be a joint public-private assembly of organizations and agencies from the entire region.

Taken as a group, the new organizational forms are superior to the modifications suggested above. They can fulfill all necessary functions as well as planning. In terms of design criteria, they are more efficient and powerful than the modifications. They can be designed to be as compatible and accountable as other organizational arrangements.

## Recommended Organizational Form

The organizational and financing requirements discussed in the previous section lead to the recommendation to establish a Regional Public Transportation Authority (RPTA).

The recommendation for an RPTA does not arise from the desire to avoid the complexities of the existing transportation decision-making process in the Triangle Area. In fact, existing entities should play a major role in designing any new organization. Rather the objectives are effective planning, coordination, and service delivery. The six options described in the previous section, which represent modifications of existing organizational structures, do not have the potential to achieve all of these vital objectives.

Of the new organizational forms, each is deemed to be about equal in terms of potential operating efficiency since each

should be able to plan, market, finance and deliver services. Selection of the authority form is based on the criteria of compatibility, accountability, and legal powers rather than operational efficiency.

The RTSD would be less compatible with existing transportation entities than the other two alternatives because it would function as a separate unit of government. The RTSD would also be far less accountable because it would have the powers to tax, issue general-obligation bonds, receive intergovernmental revenues and otherwise operate as an autonomous jurisdiction. It may be viewed as a threat to existing jurisdictions.

An RPTA is preferred to a RTMA because most advantages of an RTMA can be incorporated into a properly structured RPTA, but the reverse is not true. The major advantages of an RTMA are the flexibility to operate as a private, non-profit entity, the active involvement of the private sector, and the ability to receive private funding. An RPTA can involve the relevant private actors and receive private funds. An RPTA is more compatible than an RTMA because most important decision-making entities are in the public sector. It can be made more accountable than an RTMA because it is created by state legislation and controlled by local governments. The RPTA's legal powers outweigh an RTMA`s flexibility in providing the needed public transportation services.

The RPTA should be responsible for coordinating all public transportation services and for providing services outside and between existing urban service districts. The RPTA should be able to analyze travel demand and identify future congestion problems, work with state and local highway planners and local transit operators to identify cost-effective solutions, and operate transit services to address identified transportation needs.

The RPTA should have the power to collect fares for the transit services it provides and to issue revenue bonds to finance necessary capital equipment and facilities. It also should be able to receive grants from local, state and federal jurisdictions and contributions from major employers to help fund authority overhead and operations. The RPTA should be capitalized by the entities represented on the governing board and should have the capacity to impose fees and special assessments to garner an adequate resource base. License and registration fees could be increased to help fund the RPTA. Special assessments could be levied on transportation-related transactions (for example, gasoline sales) or on real estate developments generating significant transportation impacts. Such impact fees and assessments represent subsidies for regional public transportation services from new residents and highway users.

Although not a general unit of government, the RPTA should enjoy a permanent existence, substantial independence, and unified management. As noted above, unified management should promote internal efficiency and effective service delivery. A permanent existence creates a presence that must at least be considered, if not involved, in transportation decision-making processes in the Triangle Area. Reasonable autonomy assures that the authority will be responsible for the success or failure of its activities which will increase its accountability to its commissioners and to the public.

To be accountable to the public, a board of commissioners should be established to set policies for the authority and hire its executive director. The commissioners should have staggered terms of a fixed length to allow turnover without disrupting continuity. The elected officials of each jurisdiction should appoint its commissioner(s). The number of commissioners is less important than the relative weight of each member jurisdiction. The population size of the jurisdiction is one criterion for allocating slots. The extent of participation by the state, the Research Triangle Foundation and other public and private entities would have to be determined. The RPTA will be held accountable to the public through its commissioners. The RPTA could also be responsive to public opinion by holding hearings to receive public comments directly on its proposals.

The RPTA should develop a special set of relationships to the Research Triangle Foundation, the Raleigh-Durham Airport Authority and the Triangle J Council of Governments. The Research Triangle Foundation is responsible for circulation within the Park. Clearly, the RPTA should coordinate services with the Park. Furthermore, the Foundation is concerned about development surrounding the Park. The RPTA should join forces with the Foundation and the RTP Owners and Tenants Association to influence the development decisions made by the Durham and Wake County Commissioners.

The RPTA should work with the Raleigh DurhamU Airport Authority to coordinate surface and air transportation. The Airport is becoming and will continue to become a major employment center in the region with the opening of the American Airlines terminal. The region would be well served by improving overall transportation services while better coordinating ground and air transportation. Finally, the airport authority offers a model which may be useful in designing the RPTA.

There is a role for the RPTA in making land use and zoning decisions which shape the pattern of regional development. The RPTA staff should work through its commissioners and the Triange J Council of Governments to provide forums for discussing development. Influencing land use is important because, as noted in Report No. 2, land use patterns generate the trips which must be supported by the region's transportation system. In turn, the availability of transportation affects development.

The RPTA should devote resources to educating the public and its representatives about the need for greater density in residential development along specified corridors. Presently, the density issue is confused with the growth issue. The amount of overall growth sustainable in the Triangle Region is an important question, but the distribution of any amount of growth is a different question. Clearly, higher density is an effective way to reduce congestion and protect valuable open space with any amount of growth. The RPTA should work with public bodies and private developers to encourage cluster developments and protect open space in the region. Such residential clusters along major corridors will probably be needed before the region could be served cost-effectively by a light rail transit system.

## Getting Started

Regional public transportation needs a champion to become a central public issue. Leadership is needed to build a public transportation constituency and to develop a concensus around the preferred options. If sufficient enthusiasm exists to start a RPTA, it should be tapped to raise revenues. As a creature of local jurisdictions, the RPTA should have the greatest opportunity to attract funding from these jurisdictions without discouraging contributions from the private sector. Initial funding could be used to cover organizing costs with any surplus going into a trust fund.

Besides initial contributions, external sources of continuous support should be sought. These sources include employer contributions for employee services, special assessments on property owners for transit facilities, off-site impact fees on new development, contributions by municipal, county, state and federal governments from funds that these units raise from various levies, gasoline taxes, and vehicle registration fees.

Gasoline taxes and vehicle registration fees are among the most lucrative and sustainable external sources. In the case of gasoline taxes, funds for the RPTA would be raised in proportion to the gasoline consumed in the region. In the case of registration fees, funds would be raised in proportion to the vehicles owned by area residents and businesses. The state and the localities have to agree to take these actions in support of the RPTA given the competing need for highway funding. Since these preferred external sources are public sources of funds, the RPTA would have to remain accountable to the public for the quality and cost of service to insure continued financial support.

Financing is a critical part of the effort to establish the RPTA. If adequate funding cannot be earmarked for the RPTA, the public would be better served by not establishing the entity. A serious effort to create a RPTA includes securing sufficient initial captialization and on-going funding to let the RPTA become a viable organization.

## APPENDIX A
## FINANCING ALTERNATIVES

Alternatives for financing public transportation improvements in the Triangle Area can be grouped into four categories: fees, taxes, grants, debt and extraordinary sources. Several subgroups are identified within each of these primary groupings, and examples of how each type of funding source has been successfully used in other cities are given.

User fees are a method of financing transit that imposes the costs of operating the service on the actual consumers of the service. Before the automobile proliferated, the urban transit systems operated for profit, and users paid the full cost of providing the service. Today's transit systems, facing dispersed residential patterns, high labor costs, and intense competition from the automobile, cannot fund conventional operations with user fees alone. However, ridesharing is often funded exclusively from user fees. The 3M Company in St. Paul sponsors one of the nation's largest employer vanpool programs with operating and capital costs of the service covered by passenger fares. The 3M subsidizes administrative costs which include matching commuters with vanpools and paying a company transportation coordinator.

This vanpool program applies the benefit principle in that direct beneficiaries of a transportation service--employees--pay for the service. Employers also benefit from transit services, through reduced traffic congestion in and around the work site and through reduced employee parking needs. Development regulations in the RTP provide little incentive to reduce the availability of parking.

Many North Carolina employers subsidize public transportation currently. For example, apartments owners, technical schools, and churches oftern pay subsidizes for their clientel. Major employers such as RJR fund van pools and bus services for employees. With the encouragement of the Charolotte uptown Development Corporation, businessmen are paying for express bus service and bus passes. Aetna, Duke Power and other major companies are also involved. Financing strategies such as these could be implemented in the Triangle area with cooperation from area employers.

Other fees could be imposed as well. North Carolina cities are currently authorized to levy registration and liscensing fees on motor vehicles. Cities could increase these fees and earmark the increase for public transportation. The City of Kenosha, Wisconsin applied a vehicle registration fee on all automobiles in the city in 1977, earmarking the fees for public transportation. A subsequent study by the Wisconsin Department of Transportation concluded that all localities in the state could have funded their operating subsidies through a $12.50 per vehicle registration fee dedicated to transit. Fees might also be imposed on auto sales or on vehicle repairs, although the

state legislature would have to pass enabling legislation to impose such fees. Many cities, including Raleigh, oppose such dedicated funding schemes.

Impact fees are becoming used more frequently for off-site highway improvements and new interchanges. Impact fees from higher density developments could also be dedicated to public transit funds. Special legislation would be required. The City of Raleigh is considering ways to establish a system of impact fees at present.

Funds will be needed to operate any effective regional entity. A combination of local, state and federal grants, fees, special assessments, and revenue bonds can be used to fund operating and capital expenditures. If the experience of other cities is replicated in the Triangle Area, the entity will not have sufficient funding from these sources alone. To have sources of cash flow that will assure its integrity over time, subsidies will be necessary. Of course, subsidies are not intended to underwrite inefficiencies. Rather, the requirement of subsidies is a certainty, even with sound marketing and efficient service delivery.

Property taxes could be increased and earmarked for public transportation, but given the general opposition of voters to increasing property taxes, this is not a realistic alternative. Moreover, state legislation would be required since the state does not currently allow property taxes to be expended for public transit without a local referendum. Some areas do finance transit through property taxes. The Minneapolis-St. Paul Metropolitan Transit Commission imposes a state-authorized regional property tax to fund the transit system's operating deficit. Topeka, Kansas and Madison, Wisconsin also levy a property tax to fund public transportation. Winston-Salem has a modest fund for public transportation funded by property taxes.

Special assessments can be imposed on property identified as gaining special benefit from public transportation operations. San Francisco has designated all downtown office space as a special benefit assessment district. Other cities impose special assessments on downtown property around transit/pedestrian malls and subway stations. North Carolina cities are not authorized to levy special assessments for public transportation projects, and enabling legislation would be required. Special assessments can be levied to finance street improvements, however.

Gasoline taxes are levied by some cities to finance public transportation improvements. San Diego funded 87% of a $98 million light rail project with revenue generated by an earmarked gasoline tax. Chicago also levies a five-cent gas tax to fund transit operations.

Sales taxes are imposed by a number of cities to fund transit improvements. Houston voters approved a one percent sales tax in 1978, prior to the formation of the Metropolitan

Transit Authority, which took over operation of the city's bus service from a private operator. The tax funded new buses, expanded service and other improvements. A well-known transit sales tax has been imposed by Dallas, which intends to fund the entire construction costs of a downtown subway and metropolitan rail system with the tax. Denver imposed a 0.5 percent sales tax in 1973 that was to fund a rail system. The rail system was never built, but the city decided to substitute the sales tax for $1.0 million in property tax earmarked for transit. In the Atlanta area, a one percent sales tax is levied by Fulton and DeKalb Counties to fund MARTA. North Carolina cities are not currently authorized to impose sales taxes but may receive some funds from county-imposed sales taxes.

Intergovernmental grants represent transfers of tax revenues and are the way that local transit projects have been traditionally funded. Gasoline taxes are levied at both the federal and state level, and an increase at either level could be earmarked for transit, with revenues being channelled to local transit projects. Given current low gas prices, an increase of several pennies per gallon would not be too burdensome but would remain controversial.

Of course, UMTA funding will remain an important part of any successful program in the Triangle Area although total available resources are declining. NCDOT could use some of the state's allocation and existing surplus for new transit services.

General Obligation bonds are a form of debt used in some cities to finance both capital and operating expenses for transit. Issuance of bonds for captial expenditures allow the costs of a project to be spread over its useful life, and allow the flow of bond repayment to be roughly matched to the flow of benefits from the project. Issuing G.O. bonds to cover operating deficits is a much more questionable practice.

Revenue bonds may be issued by profitable public enterprises. For example, San Francisco used bridge tolls to secure revenue bonds for construction of the trans-bay BART tunnel. The Port Authority of New York and New Jersey also secures bonds for transit with bridge and tunnel tolls. Revenue bonds can also be secured by specific new taxes or by tax increases. Regional transit authorities in Denver, Cleveland, Atlanta and San Franscisco have used this mechanism to finance improvements. Most transit authorities cannot issue revenue bonds because they have not generated operating surpluses. However, there may be profitable public transpotration options designed to meet the needs of communities in the Triangle Areas.

Equipment Trust Certificates have been used by the Southern California Rapid Transit District (SCRTD) to borrow money for capital equipment. Certificates are sold to trustees who hold title to the equipment, and the transit operator leases the equipment for payments equal to the debt service. Interest

earned is tax-exempt under federal law if the issuer of the certificates is a public agency.

Extraordinary Sources include lotteries and voluntary contributions. Lotteries have been established in Arizona and in Pennsylvania to fund transit services. Pennsylvania established a state lottery in 1972 to allow senior citizens to ride free on transit systems in the state. Arizona's lottery funds more general services.

Contributions from private sources hold some potential as noted above. Employers have contributed to specific projects as part of efforts to ease transportation problems.

## APPENDIX B
## TRANSPORTATION DECISION-MAKING IN THE TRIANGLE

This appendix discusses the existing decision-making processes, first considering public sector decision-making and then discussing private sector decision-making.

### Public Transportation Decision-Making

Public-sector transportation decisions that are currently made in the Triangle region focus on the construction and maintenance of highways and the provision of public bus services. While important differences exist in how each of these modes is planned and developed, they are both considered within the same overall transportation decision-making framework. It is appropriate, therefore, to discuss first the framework and then the differences in how highways and transit decisions are made within this framework. Two coordinating mechanisms exist, the Metropolitan Planning Organization (MPO), and the State Board of Transportation (BOT). The MPO is intended to coordinate transportation decisions in a metropolitan area, and the BOT does the same on a state-wide basis. The MPO is a federal requirement placed upon all states, whereas the BOT is a state-established body with decision-making authority for transportation expenditures in the state.

The process of making transportation decisions begins at the local level. Transportation needs and proposed remedies are first identified by local jurisdictions in conjunction with the NCDOT Division of Thoroughfare Planning. According to federal requirements, the needs and proposals of individual cities are then taken to the Technical Coordinating Committee (TCC), which is a body composed of transportation technical staff from member jurisdictions and the Transportation Advisory Committee (TAC). The TAC is composed of local elected officials representing member jurisdictions. The TCC reviews and makes recommendations on the proposals received from individual local jurisdictions. The TCC passes its recommendations and priorities to the TAC. According to federal requirements, the TAC is required to review,

modify, and approve the projects and priorities presented to it by the TCC. The resulting product is a list of specific transportation projects which the TAC would like implemented during the next several years. This product is called the Transportation Improvement Program (TIP), which represents a multi-year schedule of transportation projects. Each year the TAC revises and updates the TIP.

Once approved by the TAC, the TIP is sent to the Board of Transportation and to the Urban Mass Transportation Administration (UMTA). The BOT has the authority to approve highway projects and authorize the spending of state funds to construct or operate them. For transit projects, the State of North Carolina has a second body, the Public Transportation Advisory Council, which advises the BOT on the appropriateness of transit projects.

In the Triangle region, there are two urbanized areas. Each of these urbanized areas conforms to the federal guidelines and has a TCC and a TAC. The Durham MPO includes Durham, Chapel Hill and Carrboro, while the Raleigh MPO encompasses Raleigh, Cary, Garner, and Apex. Thus, two TACs and two TCCs make decisions regarding transportation projects in the Triangle. The TACs and TCCs have begun to meet jointly.

The TCC-TAC process, which is intended to force regions to place priorities on projects, does not always result in firm sets of priorities. Once individual cities submit their projects to the MPO, they sometimes continue to lobby directly with the BOT for project approval. The MPOs, therefore, are not so much priority-setting bodies as they are clearinghouses in which individual jurisdictions are made aware of each others' proposals. Priorities are established ultimately by the BOT for the state rather than on a regional level.

Third, state government assumes a major role in the provision of highways in North Carolina. The North Carolina Department of Transportation (NCDOT) performs thoroughfare planning for almost all cities and towns in the state and for most of the local jurisdictions within the Triangle region. This thoroughfare planning process provides the basis for the highway projects that cities and towns submit to the TCCs and the TACs. On the other hand, the state has little direct role in the provision of public transportation services. Public transit planning is almost entirely a <u>local</u> activity. Cities and towns with public transportation services and those considering implementing such services conduct transit studies either in-house or through contracts with private consulting firms. The NCDOT provides a limited amount of funding and staff technical assistance to localities. These transit-related studies often result in transit services or capital expenditure requests that are submitted by the city to the TCC and TAC.

The funding arrangements for highway and transit projects differ in important ways. For highway projects, state funds

provide the capital match needed for federal funding. (Recently, because of the shortage of federal funds some cities and towns have offered to use a portion of their own tax revenues to help pay the cost of some highway improvements beyond the cost of right-of-ways.) For transit projects, local governments have traditionally and invariably been required to pay some portion of the cost. For capital expenditures, the local share usually has been 10 percent with the state providing 10 percent and the federal share being 80 percent. For transit operating costs, the state provides no funds. Cities and the federal government have shared the net operating costs approximately equally.

These differences between highway and transit decision-making give the NCDOT a much more important role in highway decision-making than in transit decision-making. Furthermore, the NCDOT already provides an important regional highway coordination role by planning, designing, and building major regional facilities such as I-40. Given this state role, regional coordination exists only in the highway planning area. Less regional coordination in the planning and provision of public transportation services exists because these services are locally planned and operated. Although the three largest cities in the Triangle region each has transit service, none of these transit systems are linked together at present.

## Private Transportation Decision-Making

The Triangle region has an unusually important group of private decision-makers located in the Research Triangle Park. As discussed in Report Number 1, the Research Triangle Park not only is an important factor in fueling the growth of the region but also is a major employment center for the entire region. How the Park's decision-makers deal with their transportation problems directly impacts how the region as a whole responds to its transportation challenges. Furthermore, the Park represents a precedent as other employment centers grow in importance (for example, Raleigh-Durham Airport, Treyburn and other major development projects).

Two entities make decisions for the Park. The Research Triangle Foundation is responsible for developing the Park and owns the undeveloped land in the Park. The Foundation has authority to build roads and to make other public improvements in the Park in accordance with appropriate public regulations governing private land development. Recently, the Foundation commissioned a study by Wilbur Smith and Company which identified approximately $12 million of roadway improvements that are now needed in and around the Park.

The second entity is the Park Tenants and Owners Association, a body composed of representatives from organizations with facilities within the Park. Recent enabling legislation passed by the North Carolina General Assembly resulted in the creation of a Park Service District. The Tenants and Owners Association is the body which makes decisions on

whether or not to tax Park occupants in order to fund services provided through the new service district. Thus, the Tenants and Owners Association will increasingly function like a city council in setting priorities and in funding services within the Park.

Other private entities make decisions which impact transportation services in the Triangle region. These include a number of private transportation providers such as Duke Power Company which operates under a long-term franchise from the City of Durham, Duke University, which provides transit services using its own vehicles, and Raleigh Transportation Services, which provides services to North Carolina State University, Wake Tech and other private and public entities.

The extent to which private operators and providers are included in the public decision-making processes is an important factor in transit funding because UMTA recently issued guidelines promoting private sector involvement in public transit programs. These guidelines require local jurisdictions to talk with and to include private operators in their planning processes. Although the Research Triangle Foundation is represented on the Durham and Raleigh TACs, and one private operator is on the Raleigh TCC, public and private communication and coordination remain low. To date, the private-sector has not been involved in building transportation facilities or in sponsoring public transportation services in the Triangle region.

There are two roles for the private sector in the provision of public transit services. One is as an operator, such as Raleigh Transportation Services. The other is as a sponsor of public transportation services. Many employers across the country and major developers already sponsor transit services. In the Triangle region several apartment complexes sponsor shuttle services for their residents.